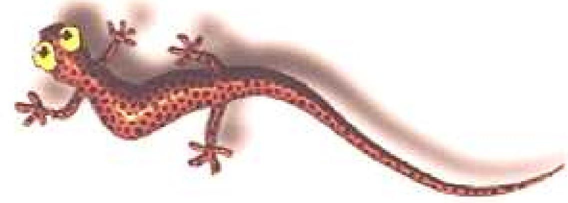


VIRGINIA'S WATERSHEDS

LOVE-A-TREE 2002

Environmental Education Activity Book For Elementary School Teachers

Table of Contents

Information provided by the member agencies of VRUEC.

What's Your Watershed Address?

Construct a simple model to demonstrate how water flows through a watershed and identify your watershed address.

Watershed Background

While we all reside in a watershed, many of us do not even know what one is or its name. A watershed, also called a drainage basin, is a geographic area in which water drains into a common body of water. Water travelling over land can carry soil sediments, dissolved minerals, livestock and pet waste, fertilizers, pesticides, and other pollutants, including trash and litter. Each watershed has unique features and potential sources of pollution.

There are nine major watersheds or river basins that lie within the state of Virginia. They are from south-west to north-east: The Tennessee-Big Sandy, the New, the Roanoke, the Chowan, the James, the Potomac-Shenandoah, the Rappahannock and the York. The James River is the largest watershed. It includes all or parts of 39 counties and 18 cities and drains one-fourth of the state's land area into the Chesapeake Bay.

Science SOLs:
3.9, 4.8, 6.11

Objectives:
Students will be able to predict where water will flow in watersheds, describe drainage patterns in watersheds, and identify sources of pollution.

Materials:
Provided in the 2002 LAT box is aluminum foil, an aluminum tray, a spray bottle, and powdered drink mix.

Vocabulary Words:
erosion
groundwater
hydrologic cycle
nonpoint source pollution
nutrients
pollutants
runoff
water pollution
watershed

Pre-activity Discussion

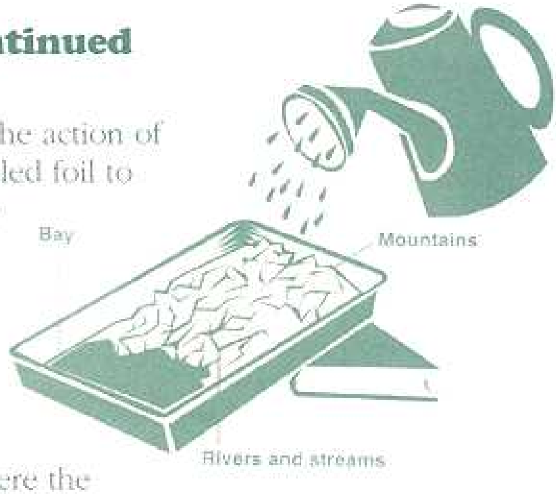
Discuss the concept of a watershed and how water travels over and through the land. Students may wonder where water goes after it flows down the street during a heavy rainstorm. Provide some examples of how individuals (including pet owners) and businesses use water and how their actions might affect water running off the land. Don't forget to include sewage treatment plants, homes, commercial developments, farms, and factories. You want to help students make the connection between people living in the watershed and the impacts that they have upon water quality; especially, non-point source pollution. Non-point source pollutants are those that can not be traced to a singular source such as a factory discharge pipe. See "Cooking Up Trouble" for more information.

Discuss the speed at which water flows and how moving water changes the land. You can refer to the branches on a tree, or the veins in a leaf, or the human nervous system to describe how bodies of water "branch out" with smaller branches analogous to streams branching into larger ones, such as rivers, and so forth. Explain that watersheds can be open or closed depending on where the water drains. In closed systems, there is no outlet for the water, so it leaves the system naturally by evaporation or by seeping into the ground (becoming groundwater). In open watershed systems, such as those found in Virginia, water eventually flows into outlet rivers or a bay and, ultimately, the sea.

Demonstration

There are several ways that students can build a three-dimensional map of a watershed, ranging from individually constructed models made of foil or plaster of paris to larger scale models created by using a shower curtain or plastic tarp.

What's Your Watershed Address? continued



The simplest way to demonstrate topography and the action of water flowing through a watershed is to use crumpled foil to create a miniature watershed model. Shape a piece of foil into a mountain or mold it over some crumpled newspaper placed in the aluminum pan. The highest points on the foil represent the mountain tops and the lowest wrinkles, the valleys. Ask the students to identify the highest points which are the mountain ridge lines and predict where the creeks, rivers, and lakes are (where the water would flow from the mountain). Sprinkle the powdered drink mix on the model to demonstrate how pollutants flow through the watershed. Use the spray bottle filled with water to lightly spray the model. The spray represents rain falling onto the land. The colored drink mix represents how pollutants flow through the watershed.

You can place sponges at the bottom of the watershed to represent wetlands that help absorb and filter the water. To show how wetlands help to hold and clean water, you could conduct a test (either using two trays or tray with two different test runs) to see which watershed drains more quickly and how much water reaches the end of the tray. In either case, measure the water before you spray it into the watershed and again, afterwards. You could also time the contest.

Inquiry Questions:

1. Discuss how the water travels through the system.

   - What changes do you observe in the "foil" watershed maps?
   - Where does erosion occur?
   - What happens to human settlements — are any buildings in the way of a raging river or crumbling hillside?
   - How does the flow of water through the watershed affect choices for building sites?
   - What happens to the "pollutants," — where do they end up?
   - What factors may lead to increased pollutants such as run-off from sediments, industrial wastes, phosphates and nitrates from agricultural sources, sewage, and residential runoff including pesticides?
   - What are some ways to reduce or prevent these "non-point" source pollutants? How could you slow down water so it will filter the runoff?
   - How does water conservation help water quality?

2. Use the accompanying map on page 5 to identify the river basin or "Watershed Address" of your community.

What's Your Watershed Address? continued

Variation

For a large scale model, use a white vinyl shower curtain as the base. Place some objects such as buckets and boxes, or even a chair (lying on its side), under the shower curtain (or a plastic tarp) to represent the mountains and follow the steps listed above. This scenario is best done outdoors! You can also add some small toys to represent land uses (cows and tractors to represent farms, cars and people or houses for residential areas, a bulldozer for development; etc.) Let the students name settlements and waterways on the model. Use your imagination!

This lesson is adapted from What's A Watershed? published in *Bay BC's* available from the Chesapeake Bay Program. (www.bayeducation.net)

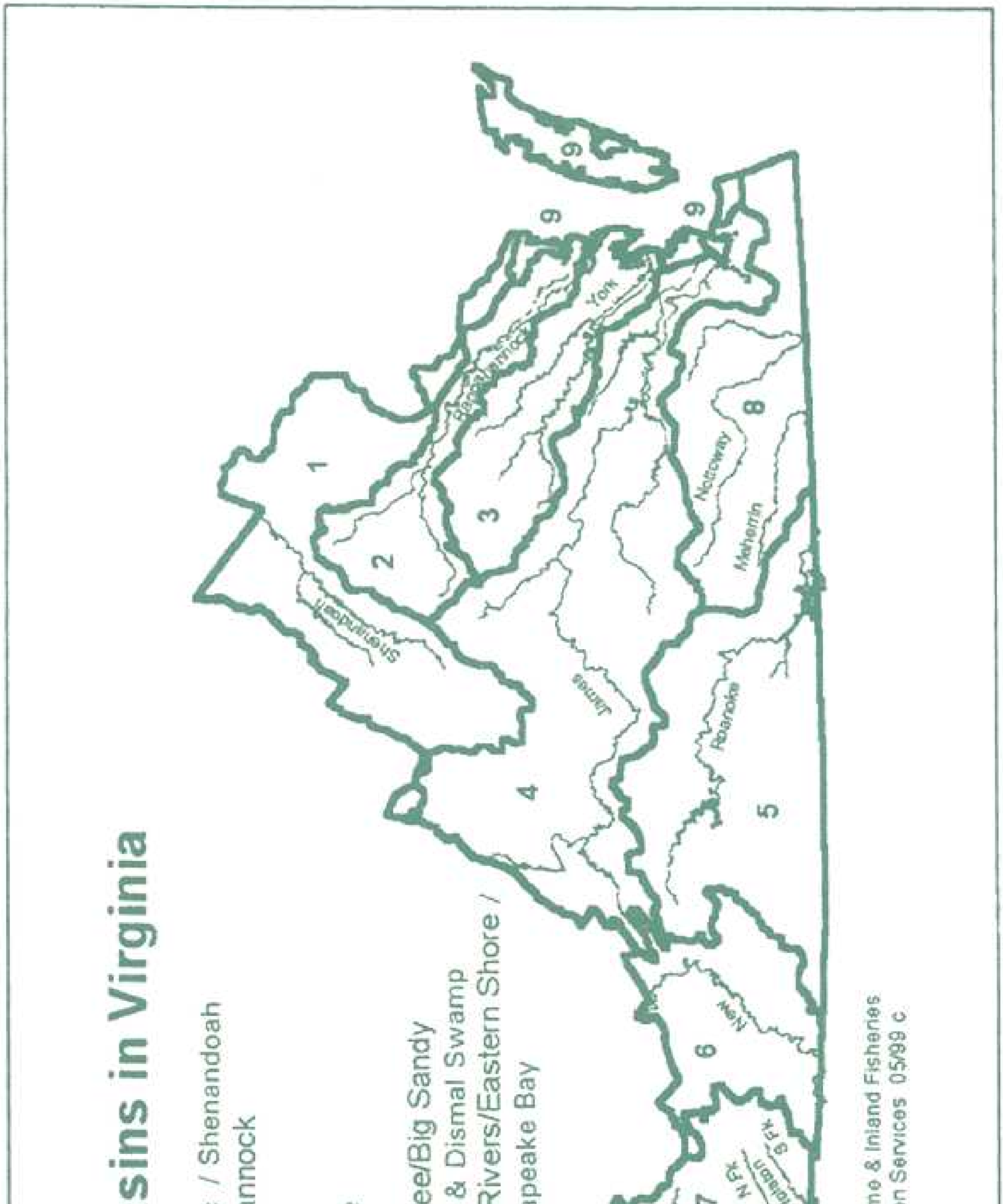
For more lessons about watersheds, check out the following lessons from Project WET:

- **"Branching Out"** - Instructions for students to make a permanent model.
- **"Rainy Day Hike"** - Elementary students collect data about water flowing over the school grounds.
- **"Color Me a Watershed"** - Students interprete maps to analyze how land use changes affect a watershed.
- **"Sum of the Parts"** - Students investigate the cumulative effects of nonpoint source pollution.

The 500 page Project WET guide filled with more than 90 lessons is available to teachers who attend a free workshop. For more information, dive into the Virginia WET web page at www.deq.state.va.us/education/wetinfo.html.

PROJECT WET
Water Education for Teachers

DEQ
Virginia Department of Environmental Quality


River Basins in Virginia
1 - Potomac / Shenandoah
2 - Rappahannock
3 - York
4 - James
5 - Roanoke
6 - New
7 - Tennessee/Big Sandy
8 - Chowan & Dismal Swamp
9 - Coastal Rivers/Eastern Shore / Chesapeake Bay
Shenandoah
Rappahannock
York
James
Roanoke
Nottoway
Meherrin
New
Clinch
Powell
Holston
N Fk
S Fk
Virginia Department of Game & Inland Fisheries
Fish & Wildlife Information Services 05/99 c

Cooking Up Trouble

A "demonstration" to introduce the concept of nonpoint source pollution and its impact on watersheds.

> **Materials:**
> A big bowl of water, big serving spoon, turkey baster, a sheet cake pan, several sponges, chef's hat and apron, and a variety of containers filled with different nontoxic ingredients to represent: litter, oil products, manure, fertilizers and pesticides

"How about a cooking demonstration?" (Put on a chef's hat and apron) My best recipe is "Cooking Up Trouble", and I have all of my ingredients right here:

First, I start with the mixing cup of _________ County water. You know, we have wonderful water in _________ County... I bet you've seen some of the springs and streams we have when you go on a hike... nice and clean. You can even jump right over some of the tiny streams, because we're right at the headwaters of *name of river* . The headwaters of these watersheds start right here in _________ County, just clean as they can be.

But, before the streams leave _________ County, some of them have gotten so many pollutants in them that we are having to do a lot of work to clean them. Now I have two questions:

1. What pollutants could possibly get into our clean water?
2. Who could possibly put them there?

Do you think it's somebody from over in West Virginia who comes over at night and puts pollution into our streams? (Laughter) Or maybe it's some factories in Chicago or Mississippi?

Well, as much as we might like to think that, it's probably not someone else. It's got to be us! But it's not any one of us in particular. We can't point a finger at someone and say, "Stop that!" It's sort of all of us, and we call this kind of pollution "Non-point source", because you can't point a finger at it.

Now what kind of pollutants do you think could get in our water? (Wait, or rummage around in your ingredients... its OK if kids get a hint from looking at your labels). Usually the first suggestion is "Litter". You're right of course. Litter can be just about anything, either dropped by accident in the water, or left lying on the ground in the watershed. Whenever it rains, anything on the land tends to wash down into the streams and rivers, including litter. Here's an old gum wrapper. Let's put that in to represent all kinds of litter, from aluminum cans to old mattresses and cars. (Give the kids a minute to tell about the litter they have seen, and maybe add, "Yeah people used to think that rivers were a good place to get rid of trash, but we know better now!")

Wait a few seconds for someone to suggest another pollutant, and, if no one can think of anything, pick up an ingredient. Be careful not to accuse or indict anyone in particular, but be positive and up beat about all the better possibilities we know about.

Oil products: (Use bulb syringe to squirt some of the water from the container with a a little vegetable oil in the top). I bet you've been to the mall when it's raining, and seen

Cooking Up Trouble continued

those beautiful rainbows on top of the puddles… where do you suppose that oil goes if it keeps on raining? You're right, into the stream. This could be oil, gasoline, or brake fluid, lots of oil products.

Soil: (Sprinkle some soil in and whisk it up). How could soil be a pollutant? It's a natural substance! But whenever we take off the grass and trees from a field or construction site or road, a lot of soil washes away - enough soil to make the streams look like soup. How would you like to be a fish in one of those streams - trying to pump this water through your gills? Yuck! That's why we have good laws to get people to plant grass right away when they are building something.

There are two other problems with soil pollution in water. One is that we need to keep our soil right where it is, not down in the Chesapeake Bay. It takes 100 years to make an inch of topsoil, but only one good rainstorm to wash it away. The other problem is that soil in the water blocks the sunlight from growing the Submerged Aquatic Vegetation - the good plants that grow in and around the streams and rivers, which help to put oxygen in the water.

Manure and Poultry Litter: (Sniff and sprinkle). I bet you've seen some of the nicest cows walk down to the stream for a drink, and they stay there to poop! Cows are pretty hard to potty train! And then they have to drink poop water too! We love our cows but we don't want them to poop in our water. We also want to let the bushes and trees to grow around the streams to keep them clean, and cows do a pretty good job of stomping or eating them too. So we've gotten smarter about fencing our cows out of our streams and piping the clean water into the trough for them. We know that manure and poultry litter are good fertilizers for growing crops too, but we have to be really careful about how much we put on, and when, so that it doesn't get rained into the streams.

How about people poop? Out here in the country, we have septic systems, where the bacteria can take care of whatever we flush. Then the clean water can percolate through the sand and gravel. But only if our septic tanks are working right, and get cleaned out every couple of years. In our towns we have sewage treatment plants, where we have lots of good bacteria and oxygen stirrers. We have to take extra good care of them to be sure that the water coming out of them is clean before it gets into the river too. We know that we have a few septic problems here in the country, so let's put in a squirt of leaky septic fields too (same container as oil products).

Fertilizer: (Sprinkle in and whisk). There must be some kind of contest to see who can put the most fertilizer on their lawns. Have you seen those giant piles of fertilizer at the store in the spring? It's a trick, I think, to keep you all mowing all summer! We all know that grass just can't use all the fertilizer we put on. So what happens to all that extra fertilizer? Yes, It becomes part of our non-point source pollution recipe.

Wait, what's this? Salt? How could salt get into our rivers? How about in the winter when the roads are icy, and we need to put salt on them to stay safe. We have to be really careful not to spread salt right by the creeks, though.

Cooking Up Trouble continued

Anything else? What about this acid rain bottle? Where does acid rain come from? It's another one of those non-point source problems too. When we all drive our cars, the exhaust goes up into the atmosphere and contributed to acid rain. And, when we turn on all of our electric appliances, we are asking the power plant for more electricity. Guess how most of our electricity is made... burning coal. It's just like saying "Hey could you put another shovel of coal in the power plant for me?!" We can get the electricity we want, but we also get the coal smoke we don't want... because it causes air pollution and acid rain. It makes me sure to turn off the lights and TV when I leave a room!

Oh yeah, we have some pesticides and herbicides in here. Remember that lawn fertilizer? Often people put in some weed killers (herbicides) at the same time as the fertilizer, and call it "Weed and Feed". I don't know why everyone hates dandelions so much! But if it comes to a choice of clean water with dandelions or polluted water without dandelions, I bet we'd learn to get along with them! There are lots of ways to trick some of our bug pests besides spraying all of them, and we're getting smart about that too.

Now we have really cooked up a mess, haven't we? We really can find and measure these pollution ingredients in ____________ County water too, and we need to find ways to clean them up. Wouldn't it be great if we could keep these pollutants from running off into the streams in the first place? If you wanted to invent a way to catch them before they got to the stream, how would you do it?

(Give kids a chance to give their ideas, and praise the merit in all of them)

You know, Nature already has a really good system that can take care of most of these pollutants, if we let it - it's trees and shrubs, growing all along our streams, like a filter or a buffer! Just to prove a point, I brought along one with me (not as good as a natural one, but we can get the idea).

(Take out the box lid with the sponge and tell the kids that the sponge represents the roots of the trees and other vegetation, and the box lid is the watershed. The school or their houses would be on the box top above the buffer.)

Now let's give this buffer a chance to clean up some of our recipe. (Pour about 1/4 cup down the box lid, and let it pool in the sponge). Suspense is good. In fact it illustrates the principle we're after with a buffer! Whistle the Jeopardy theme song while you wait. When the water finally does begin to trickle through, begin to ask the kids what might have happened in a real buffer to those ingredients. The soil and fertilizers, manures are easy. The oil products and pesticides may be sequestered in the trees or broken down by soil bacteria. The litter can be picked up by kids on Earth Day, or will gradually decompose. And the clean water is gradually released into the healthy, cool stream, even in a drought.

Take off your chef's hat and apron, and thank the kids for making it so much fun to talk about science and good conservation. Dispose of your "recipe" into a waste container for later cleanup, as kids worry about pouring it down the drain. I usually dump it on trees at the edge of the parking lot before I leave.

Written by:
Sandy Green, Educator
Headwaters Soil & Water Conservation District

Good Litter

An activity to demonstrate the value of forests in watersheds.

Next time you rake leaves, think about the energy piling up around your feet. Green leaves have the marvelous ability to capture sunlight energy for use in making plant food. Part of this food goes for growth and maintenance; part is stored for future growth. When leaves, twigs or whole trees die and fall to the ground they bring with them lots of food and minerals. In the forest, this dead plant material forms a layer on the ground called litter.

Litter is full of life. It contains so much stored energy and essential nutrients that countless organisms use it for food. These organisms—bacteria, fungi, worms, insects and many others—are called decomposers because they reduce litter to ever-smaller pieces that mix with the soil where nutrients are taken up and reused by plants. This is one way nature recycles litter. People are learning to recycle things, too. Can you name some?

Litter is also good for preventing erosion and protecting water supplies. It acts as a sponge to soak up rain, and it keeps the soil surface loose so water is absorbed quickly. During heavy rains, excess water seeps gradually through forest soil to the water table, or into an aquifer, or to streams and reservoirs where people can use it. ***That's why forests are so important for watershed protection.*** If it rains hard on unprotected soil, then much of the water flows quickly over the surface, carrying soil and other material with it and causing erosion, water pollution and flooding.

Farmers and gardeners have known for centuries that litter protects and enriches the soil. That's why litter, mulch, compost, cover crop organic matter and related words are so important to people who grow things.

To find out for yourself how good litter is, try this:

1. Cut two plastic jugs in half as illustrated and fill them with soil. Tilt them, place litter on one, and "make rain" on them with water from a perforated can. Once it settles, the littered container will yield clear water.

2. Use the two wooden rulers from your Love A Tree Box and two bottomless metal cans of the same size. Drive one set into naturally littered soil and the other into unprotected soil. Make the same amount of rain over both rulers and pour equal amounts of water into both cans. Compare the heights that soil splatters on the rulers and the rates that water drains from the cans.

   Put samples of these two soils in separate jars, fill 2/3 with water, shake and let settle into layers according to particle size. Compare.

Good Litter continued

3. Rake up a pile of leaf or grass litter. Examine the litter and the soil underneath; record their appearance, feel and smell; note presence of any organisms; measure pile height. Let your letter stand and record changes as they occur. Examine both litter and soil underneath. Finally, take some decomposed litter from the bottom of your pile, mix it with sand and grow plants in it. Grow more plants of the same kind in pure sand. Water both groups equally. Compare.

4. Quickly place some forest litter in a plastic bag. Be sure to sample the whole layer down to the soil. Look for organisms. Sort through and sift some into a light colored contained or pan of water. Look closely for signs of life; use magnifiers. [illegible] litter in a warm, moist place (not hot or wet) to see if bacteria, fungi, or seeds begin to grow.

VIRGINIA DEPARTMENT OF FORESTRY

A RAIN GARDEN

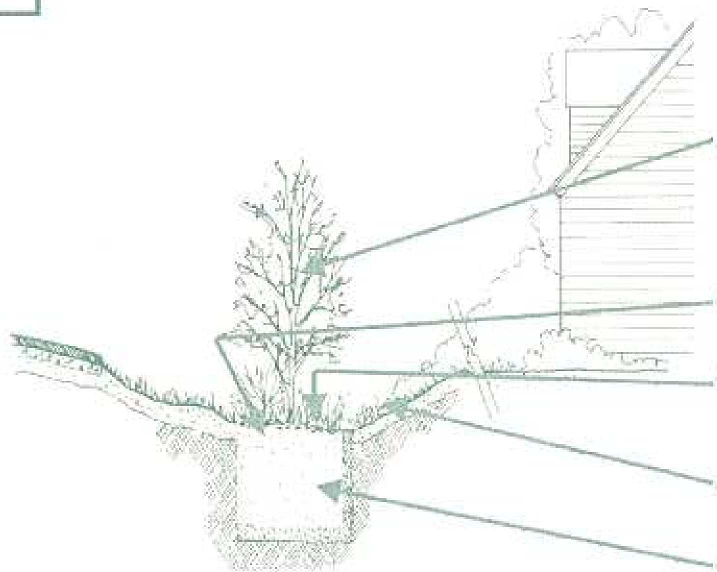
A NATURAL SOLUTION TO STORMWATER MANAGEMENT

HOW A RAIN GARDEN WORKS

A rain garden works like this: The rain garden intercepts stormwater runoff, full of pollutants from roofs, sidewalks, roads and parking lots. This excess drainage ponds in the depression of the garden. As the water soaks in, chemicals are available to the plant roots and attach to the garden's soil and mulch. The end result? Improved water quality and less surface sheet flow during rain events.

BENEFITS OF A RAIN GARDEN

- Improve water quality
- Solve drainage problems
- Eliminate soil erosion
- Increase groundwater recharge
- Provide wildlife habitat
- Create a landscape focal point
- Protect stream channels



ELEMENTS OF A RAIN GARDEN

- **Plant Selection**- Most riparian species work well in rain gardens. Include trees, shrubs and perennials for wildlife habitat.
- **Ponding Area**- Depressional area where water is stored.
- **Mulch/Organic Layer**- Removes harmful chemicals and retains moisture.
- **Grass Buffer Strip**- Slows water as it enters the garden.
- **Planting Soil**- A good soil mixture provides a source of water and nutrients for the plant to

VIRGINIA DEPARTMENT OF FORESTRY

Potomac Watershed Partnership

Adopt-A-Stream

Storm drain stenciling project

Adopt A Stream DCR

Partially funded by the Litter Control and Recycling Fund

Have you ever looked at a parking lot after it has rained? Did you notice the little rainbows on the pavement? What is that? Cars leak oil and antifreeze on the pavement.

Have you ever noticed all the cigarette butts on the side of the road at a stoplight? People throw litter on the side of the road.

What about the sand and chemicals spread on roads when it snows?

When it rains, where does all that stuff go? Down the street, into a storm drain and then into your river!

When you stencil a storm drain, it helps remind people that the water that runs off the street ends up in the river.

What else can people do to keep all that stuff from washing off into rivers?

1. Don't litter. Put trash in the proper place and remind your parents and friend to do the same.

2. If you know someone who changes the oil in their car, make sure they don't dump it on the ground or pour it down a storm drain.

3. If you see a bare spot on the ground, get someone to help you plant something there to hold the soil in place. Loose soil can wash into streams. It clouds the water and blocks sunlight. Plants, fish and other critters have a hard time breathing.

4. Be a pooper scooper. Clean up after your pet when you take your dog for a walk. Bury animal waste or flush it down the toilet so it won't wash down the street and end up in the river.

5. Clean up a stream. Get a group of friends and an adult or two and Adopt-A-Stream. Pick up the trash twice a year and then celebrate the great job you're doing to keep your river clean.

DCR
Department of Conservation & Recreation
CONSERVING VIRGINIA'S NATURAL & RECREATIONAL RESOURCES

For more information or to get a storm drain stenciling kit, call: (804) 692-0148 or visit our website: www.dcr.state.va.us/sw/adopt.htm

Storm Drain Activity

1. Have several people in your class or a few friends each take a bucket or large container of water and stand in several places in the parking lot of your school or in the driveway of your house or meeting place. Pour the water on the pavement and watch where it goes. OR notice where the water is coming from and going on a rainy day.

2. Look at a map of your county or town. Try to figure out where the water that empties into the storm drain goes. What creek, stream or river would it flow to?

SOLs:

Science: K.5, 1.1, 1.3, 1.8, 2.1, 2.5, 2.7, 2.8, 3.1, 3.6, 3.9, 4.5, 4.8, 5.7, 6.11, LS.4, LS.11, LS.12, ES.3, ES.7, ES.9, BIO.1, BIO.9.

3. Look at the parking lot or side of your street. Make a list of what you see that might wash with the rain water into the storm drain. Write down beside each thing on your list how it might not be good for the river. What can you do to help prevent each from washing into the river?

4. Stencil the storm drains at your school to remind others that the runoff goes to a nearby river. Follow the directions provided in the kit.

To order the kits, please visit www.dcr.state.va.us/sw/adopt.htm.

STREAM

BAY

LAKE

RIVER

DCR
Department of Conservation & Recreation
CONSERVING VIRGINIA'S NATURAL & RECREATIONAL RESOURCES

Journey up the Watershed

Using the video and student information provided, students learn about the American Shad

Background:

SOLs:
Science 3.4, 4.8,

The American Shad is one of the several anadromous fish species located along the Atlantic coast. Anadromous fish are spawned or born in fresh water rivers and streams, migrate to the ocean where they mature and return to the stream of their birth to begin the cycle again. A variety of anadromous fish migrate up Virginia's watersheds to spawn. Included in this group are the American and Gizzard Shad, Striped Bass, American and Shortnose Sturgeon and the Yellow perch. Of these, the Short nose Sturgeon is a federally listed endangered species.

Anadromous fish on both coasts are affected by changes in their watershed. The fish are adapted to move from fresh to salt water conditions and back again when they mature. While they are maturing in the ocean, changes that take place in the watershed can greatly disrupt their reproductive cycle. On many rivers, dams have been built to hold water or for power. These obstacles are sometimes impossible for fish to navigate past to spawning grounds.

Historically, the American shad provided a source of protein for the Native Americans each spring after what might have been a long cold winter. George Washington fed his troops shad at Valley Forge, perhaps saving our early army from starvation. Economically, the shad fishery once supported many small villages in the entire Chesapeake watershed. Currently, there is no commercial harvest of the American Shad in Virginia.

On the James River, Bosher's Dam was constructed in 1823, blocking the migration of shad to the upper reaches of the watershed. During the 1800's some shad were able to swim past Richmond through the canal system, however once railroads became popular the canal access slowly disappeared. Shad continued to spawn in the creeks and streams east of the fall line but could no longer swim the entire reach of the watershed.

The Fisheries Division at the Virginia Department of Game and Inland Fisheries has been part of the effort to restore American Shad in Virginia. Adult shad, male and female, are captured as they swim into Virginia's rivers to spawn. The adult shad are manually spawned (eggs and sperm are removed by applying pressure to the abdomen of the fish), by biologists. The eggs are taken to fish hatchery facilities to hatch. The young fish, known as fry, stay there for **4 to 7 days** before being stocked in Virginia's rivers.

The fry are stocked above Bosher's Dam in Richmond on the James River. The Game Department along with the City of Richmond and others constructed a fish way in Bosher's Dam to enable the shad to swim past Richmond to spawn. During the spawning season, March through May, your class can view shad swimming through the Bosher's Dam Fish-way on the "Shad Cam" and count the number of shad you see traveling up the watershed. For more information or to check out the shad cam visit www.dgif.state.va.us/fishing/shad/

Journey up the Watershed student page

The effort to restore shad above the fall line at Richmond has been successful, although the actual numbers are still low compared to the historical records. Fishery biologists are beginning to see wild born fish returning and spawning above the dam. These fish are young of the hatchery-reared fish that were released in the mid 1990's.

Fishy Math Questions:

Between 1994 and 2001, Fisheries Biologists from the Department of Game and Inland Fisheries released 54 million young American Shad into the James River. Hopefully, these shad swam back down the James River into the Atlantic Ocean each fall. Fish Biologists estimate that one out of 400 fry fish will return to spawn in three to six years.

1. What is the average number of fry released each year?

2. How many fish are expected to return to the James River to spawn in three to six years after they are released?

3. Assuming that half of the fish returning are female and that each female lays a minimum of 100,000 eggs each year, how many fish will return 10 years.

Mapping:

The American Shad migrates a thousand miles or more each year in order to spawn. Shad winter off the coast of Florida, swimming north each spring to the Chesapeake Bay and then up the James River. With your students, map the trip north. What other species are migrating north in the spring? Mark the beginning and final destination of each species.

Fish Can't Jump or Fly

In the Project WILD activity "Fashion A Fish, students design a variety of fish adapted for various aquatic habitats. Below is an adaptation for the problem anadromous fish that swim upstream each spring to spawn.

Background:

Each of Virginia's anadromous fish species has historically migrated above the fall line in each river to spawn. Each species is adapted to maneuver through the falls to reach the shallow water and grass beds above the falls. When the English discovered that they could not navigate pass the fall line in the early 1600's they settled along the river. The major cities found on the fall line are, Petersburg on the Appomattox River, Richmond on the James, Fredericksburg on the Rappahannock, and Alexandria on the Potomac. It didn't take long for the colonist to realize the benefits the rapid flowing water provided in powering flourmills, the iron works in Richmond and later electricity in the 1900's. As each of the cities grew, the size and number of dams to harvest the hydroelectric power of the rivers increased. Unfortunately, the fish that once migrated upriver to spawn could no longer reach the spawning grounds, since they could not jump over or maneuver around the dams.

The anadromous fish found on the Pacific Coast are adapted to jumping over the low natural falls on the western rivers. Because the eastern rivers have low irregular falls, shad, stripers and other species are adapted to swim past the large rocks that make up the fall lines.

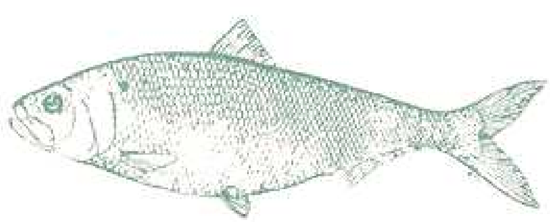
The Department of Game and Inland Fisheries and other organizations have been working to remove, cut slots in or build fish ways in the dams so that anadromous fish can once again migrate further up the watershed to their historic spawning grounds.

Activity:

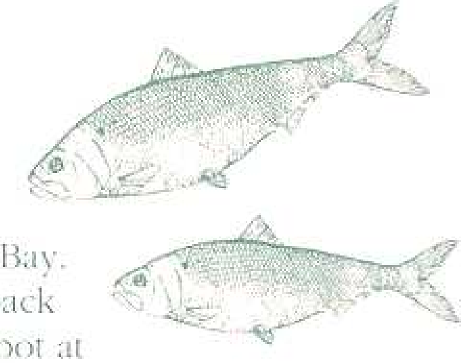
In the Project WILD activity "Fashion a Fish" students create a fish that is adapted to a particular habitat. Create an anadromous fish that would be able to make it up over the dams and through the falls on their own without the Department of Game and Inland Fisheries creating access over the dams.

The fish would need to be able to fly, jump over or walk around the dams; keep in mind that the Embery Dam on the Rappahannock River in Fredericksburg is 22 feet high.

Anadromous fish on the East Coast will return to spawn for several years, each year they are longer, heavier and carry more eggs. For example; a female, 6 yr. old, striped bass may be 2.5 feet long the first time she returns to spawn, 10 years later she may be over 5 feet long and weigh almost 100 pounds. After spawning the fish would have to get back over the dam to the Atlantic Ocean.
If a large 40-pound striper had to *fall* over the Embery Dam it may not live to make it to the Ocean.



History of the American Shad
Student page



The American shad or white shad, ***Alosa sapidissima***, is the best-known of the six species of shad and herring that swim in the Chesapeake Bay. It is a handsome fish, with a metallic blue-green back that lightens to silver along its sides and a black spot at the shoulder, with several smaller spots trailing behind. The American shad can reach a length of 30 inches, and is the largest–and considered the most delicious to eat–of all the shads.

The anadromous American shad is native to the Atlantic coast from the St. Lawrence River to Florida, and spends most of its life at sea in large schools. It only enters the freshwater river in which it was born to spawn. As the shad migrates from salt water to fresh, its skin of large, easily-shed scales dulls from blue-green to brown. Shad take long ocean migrations, spending the summer and fall in the Gulf of Maine and overwintering in deeper offshore waters. During an average life span of five years at sea, the American shad may migrate more than 12,000 miles. They enter Chesapeake Bay from January to June between the ages of four and six to spawn in the fresh water to low-salinity tributaries as far north as the Susquehanna River.

Life Cycle:

- Spawning occurs in both tidal and nontidal freshwaterwhen the river water temperatures reach 55 to 61 degrees F.
- Shad spawning runs in the Bay usually extend from the middle of February until early June, although in Virginia, spawning generally begins in mid to late March.
- Spawning usually takes place between sunset and midnight. A female lays up to 600,000 eggs, while several hovering males fertilize them.
- Shad usually migrate without feeding and move far enough upstream for the eggs to drift downstream and hatch before reaching saltwater. After spawning, adults either die or return to the sea.
- Female American shad may live as long as 10 years, but repeat spawners are rare in Chesapeake Bay waters. Historically, American shad probably spawned in virtually every accessible river and tributary along the Atlantic coast. Blockage of spawning rivers by dams and degradation of water quality, however, has severely depleted suitable American shad spawning habitat.

- The eggs mature rapidly and transform into young fish in three to four weeks. The young of the year remain in fresh to brackish water, feeding on copepods and insect larvae until early fall before entering the sea.
- Some juveniles do not enter the sea and instead overwinter in deep holes near the mouth of the Bay. The first months of life are the most hazardous; about 70 percent die before reaching the sea.
- While at sea young shad join other young shad schools and begin an impressive three to five years of coastal migration. While at sea they feed on plankton, small crustaceans and small fishes.
- After four to six years they begin to return to their natal rivers to spawn.

The Fishery:
Since colonial times American shad have been valued both for their delicious meat and roe. From the mid-1800s to the early 1900s, the American shad fishery was the largest fishery in the Chesapeake Bay, with annual catches that exceeded 22,000 metric tons. The fishery has been in decline over the past 75 years and the catch was only 700 mt in 1992 and 1993. The long decline seems primarily the result of overfishing and habitat degradation in spawning areas.

The largest local American shad commercial fishery lies along the Atlantic coast of Virginia. The fishery employs a variety of gear, but the bulk of the commercial catch is taken with gill nets. For the recreational fishery, American shad are commonly fished with dip nets or by angling with artificial lures and flies when the fish are migrating to their spawning grounds.

Measures to boost the American shad population include releasing hatchery; reared fishes and fitting dams and blockages on rivers with fish passages to allow American shad to reach historical spawning areas. The Atlantic States Marine Fisheries Commission adopted a Fisheries Management Plan for American shad in 1985, and in 1989 Pennsylvania, Maryland and Virginia agreed to conserve existing stocks under a baywide shad management plan. Even with these measures, however, it could take years for the shad population to rebuild.

Fishy Activities from Project WILD

Several activities in the Project WILD guides deal directly with issues facing anadromous fish in the Chesapeake Bay and the Atlantic Ocean. Below is a list of those activities you may want to share with your students.

- **"Hooks and Ladders"** - Students simulate the hazards faced by migrating fish in an activity portraying the life cycle of these aquatic creatures.

- **"To Dam or Not to Dam"** - Students role-play individuals representing different perspectives and concerns related to the construction of a dam.

- **"Net Gain, Net Effect"** - Students conduct a simulation to explore the evolution of fishing and the effects of changing technology on fish populations"

- **"Where Have All The Salmon Gone?"** - Students graph and interpret actual fish population data in relation to historical events.

- **"Sockeye Scents"** - Students simulate the return of an anadromous fish species up the watershed of their birth.

Project WILD is an environmental education program sponsored in Virginia by the Virginia Department of Game and Inland Fisheries and the Virginia Division of the Izaak Walton League. Participants can receive copies of the supplementary curriculum guide by attending a six-hour workshop. For more information visit www.dgif.state.va.us/education/wildlife_education.html.

VIRGINIA
Department of Game & Inland Fisheries

The Incredible Journey (excerpted from Project WET)

With a roll of the die, students simulate the movement of water within the water cycle.

(NOTE: In the printed version of the book, this activity is found in a two color, three column format. The Watercourse and the Council for Environmental Education retain all rights to this activity and the illustrations included from the *Project WET Curriculum and Activity Guide).*

Grade Level:
Upper Elementary, Middle School

Subject Areas:
Earth Science

Duration:
Preparation Time: 50 minutes
Activity Time: two 50-minute periods

Setting:
A large room or playing field

Skills:
Organizing (mapping); Analyzing (identifying components and relationships); Interpreting (describing)

Vocabulary:
condensation, evaporation, electromagnetic forces

Materials:
- 7 large pieces of paper
- Marking pens
- 9 boxes, about 6 inches (15 cm) on a side Boxes are used to make dice for the game and are included in the 2002 Love-A-Tree kit. To increase the pace of the game, use more boxes at the stations. To represent the path of water in Virginia, use the labels provided in the box or consult www.montana.edu/wwwwet/watercycl.html. For younger students, us pictures.
- A bell, whistle, or some other sounds maker

Objectives:

Students will:

- describe the movement of water within the water cycle.
- identify the states of water as it moves through the water cycle.

Making Connections:

When children think of the water cycle, they often imagine a circle of water, flowing from a stream to an ocean, evaporating to the clouds, raining down on a mountaintop, and flowing back into a stream. Role-playing a water molecule helps students to conceptualize the water cycle as more than a predictable two-dimensional path. This is a good activity to do before *What's Your Watershed Address?*.

Background:

While water does circulate from one point of state to another in the water cycle, the paths it can take are variable.

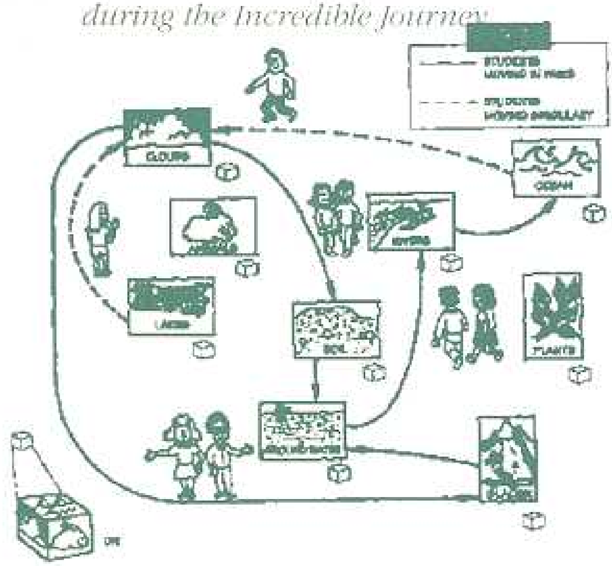
Heat energy directly influences the rate of motion of water molecules (refer to the activity "Molecules in Motion"). When the motion of the molecule increases because of an increase in heat energy, water will change from solid to liquid to gas. With each change in state, physical movement from one location to another usually follows. Glaciers melt to pools which overflow to streams, where water may evaporate into the atmosphere.

Gravity further influences the ability of water to travel over, under, and above Earth's surface. Water as a solid, liquid, or gas has mass and is subject to gravitational force. Snow on mountaintops melts and descends through watersheds to the oceans of the world.

One of the most visible states in which water moves is the liquid form. Water is seen flowing in streams and rivers and tumbling in ocean waves. Water travels slowly underground, seeping and filtering through particles of soil and pores within rocks.

Although unseen, water's most dramatic movements take place during its gaseous phase. Water is constantly evaporating, changing from a liquid to a gas. As a vapor, it can travel through the atmosphere over Earth's surface. In fact, water vapor surrounds us all the time. Where it condenses and returns to Earth depends upon loss of heat energy, gravity, and the structure of Earth's surface.

Using station illustrations, create a one page graphic on which students record their movements during the Incredible Journey.



Water condensation can be seen as dew on plants or water droplets on the outside of a glass of cold water. In clouds, water molecules collect on tiny dust particles. Eventually, the water droplets become too heavy and gravity pulls the water to Earth.

Living organisms also help move water. Humans and other animals carry water within their bodies, transporting it from one location to another. Water is either directly consumed by animals or is removed from foods during digestion. Water is excreted as a liquid or leaves as a gas, usually through respiration. When water is present on the skin of an animal (for example, as perspiration), evaporation may occur.

The greatest movers of water among living organisms are plants. The roots of plants absorb water. Some of this water is used within the body of the plant, but most of it travels up through the plant to the leaf surface. When water reaches the leaves, it is exposed to the air and the sun's energy and is easily evaporated. This process is called transpiration.

All these processes work together to move water around, through and over Earth.

Procedure:

Warm Up

Ask students to identify the different places water can go as it moves through and around Earth. Write their responses on the board.

The Activity

1. Tell students that they are going to become water molecules moving through the water cycle.

2. Categorize the places water can move through into seven stations: Clouds, Plants/Soil, Animals, Rivers, Bay, Wetlands, Ground Water. Write these names on large pieces of papers and put them in locations around the room or yard. (Students may illustrate station labels.)

3. Assign an even number of students to each station. (The cloud station can have an uneven number.) Have students identify the different places water can go from their

station in the water cycle. Discuss the conditions that cause the water to move. Explain that water movement depends on energy from the sun, electromagnetic energy, and gravity. Sometimes water will not go anywhere. After students have come up with lists, have each group share their work. The die for each station can be handed to that group and they can check to see if they covered all the places water can go. The Water Cycle Table (www.montana.edu/wwwwet/watercycl.html) provides an explanation of water movements from each station.

4. Students should discuss the form in which water moves from one location to another. Most of the movement from one station to another will take place when water is in its liquid form. However, any time water moves to the clouds, it is in the form of water vapor, with molecules moving rapidly and apart from each other.

5. Tell students they will be demonstrating water's movement from one location to another. When they move as liquid water, they will move in pairs, representing many water molecules together in a water drop. When they move to the clouds (evaporate), they will separate from their partners and move alone as individual water molecules. When water rains from the clouds (condenses), the students will grab a partner and move to the next location.

6. In this game, a roll of the die determines where water will go. Students line up behind the die at their station. (At the cloud station they will line up in single file; at the rest of the stations they should line up in pairs.) Students roll the die and go to the location indicated by the label facing up. If they roll stay, they move to the back of the line.

   When students arrive at the next station, they get in line. When they reach the front of the line, they roll the die and move to the next station (or proceed to the back of the line if they roll stay).

   In the clouds, students roll the die individually, but if they leave the clouds they grab a partner (the person immediately behind them) and move to the next station; the partner does not roll the die.

7. Students should keep track of their movements. This can be done by having them keep a journal or notepad to record each move they make, including stays. Students may record their journeys by leaving behind personal stickers at each station. Another approach has half the class play the game while the other half watches. Onlookers can be assigned to track the movements of their classmates. In the next round the onlookers will play the game, and the other half of the class can record their movements. Students can also pick up colored slips of paper at each station (clouds=white, lakes=blue, etc.).

8. Tell students the game will begin and end with the sound of a bell (or buzzer or whistle). Begin the game!

Wrap Up and Action

The Incredible Journey continued

Have students use their travel records to write stories about the places water has been. They should include a description of what conditions were necessary for water to move to each location and the state water was in as it moved. Discuss any cycling that took place (that is, if any students returned to the same station). Provide students with a location (e.g., parking lot, stream, glacier, or one from the human body-bladder) and have them identify ways water can move to and from that site. Have them identify the states of the water.

Have older students teach "The Incredible Journey" to younger students.

Assessment

Have students:

- role-play water as it moves through the water cycle (step 8).
- identify the states water is in while moving through the water cycle (step 4 and Wrap Up).
- write a story describing the movement of water (Wrap Up).

Extensions

Have students compare the movement of water during different seasons and at different locations around the globe. They can adapt the game (change the faces of the die, add alternative stations, etc.) to represent these different conditions or locations.

Have students investigate how water becomes polluted and is cleaned as it moves through the water cycle. For instance, it might pick up contaminants as it travels through the soil, which are then left behind as water evaporates at the surface. Challenge students to adapt "The Incredible Journey" to include these processes. For example, rolled-up pieces of masking tape can represent pollutants and be stuck to students as they travel to the soil station. Some materials will be filtered out as the water moves to the lake. Show this by having students rub their arms to slough off some tape. If they roll clouds, they remove all the tape; when water evaporates it leaves pollutants behind.

Resources

- Alexander, Gretchen. 1989. *Water Cycle Teacher's Guide.* Hudson, NH: Delta Education, Inc.
- Mayes, Susan. 1989. *What Makes It Rain?* London, England: Usborne Publications.
- Schmid, Eleonore. 1990. *The Water's Journey.* New York, NY: North-South Books.

PROJECT WET
Water Education for Teachers

SAMPLE PACKET FROM THE...

Teaching Virginia's Water Resources

DEAR EDUCATOR,

This Sample Packet from the new *Teaching Virginia's Water Resources* contains four sections (two chapters and two lesson plans):

Chapter: *Litter and Debris in Our Waterways*

Lesson: *Classifying Aquatic Debris*

Chapter: *Teaching the Science Process Skills*

Lesson: *Observing a Stream*

When completed later this year, the *Teaching Virginia's Water Resources* will support three important priorities in Virginia:

- Education of school children on watersheds, water quality, stewardship and management issues;
- Higher student achievement in the Standards of Learning for Science; and
- Compliance with Virginia's Chesapeake 2000 Agreement commitments to provide meaningful field experiences to all students.

This new packet containing water resource information as well as classroom and field activities will help you effectively teach the water resource-related SOLs (K–12). The *Teaching Virginia's Water Resources* materials will be available on the Internet later this year, and a limited number of sets will be printed. Curriculum materials are being created by Clean Virginia Waterways & the Science Education Faculty of Longwood University's Department of Natural Sciences. Funding is provided by The Virginia Environmental Endowment.

If you wish to be notified when the entire *Teaching Virginia's Water Resources* is published, please call or send an email to the authors:

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Litter and Debris in Our Waterways

DEFINING AQUATIC LITTER AND DEBRIS

Aquatic litter and debris are any manufactured or processed solid waste that enter the aquatic environment from any source. In short, it is our misplaced waste and trash. It is a highly pervasive and visible form of pollution that has harmful impacts on wildlife and human health.

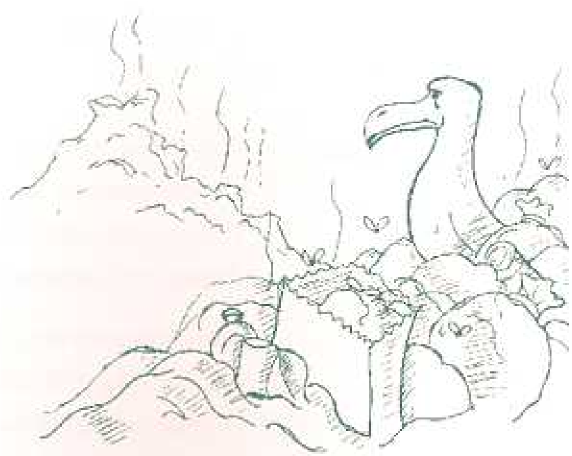
Aquatic ecosystems–streams, rivers, wetlands, and estuaries–are under considerable pressure from human activities, including incorrect disposal of trash. While the world's oceans are vast, they do not have an infinite ability to safely absorb our wastes. Preserving and restoring the quality of freshwater and marine environments requires that we understand how much trash we create, what we do with that trash, and how we can prevent it from entering our waterways.

SOURCES OF AQUATIC DEBRIS

According to the Ocean Conservancy, all the trash in our water shares a common origin: "...at a critical decision point, someone, somewhere, mishandled it, either thoughtlessly or deliberately."

Some debris originates from the sea and inland waterways. This includes debris from ships, boats, offshore drilling platforms, and offshore rigs.

The rest of the debris we find in our waterways comes from land-based sources, including people who litter, landfills, and storm drains. Another source of land-based debris is from *combined sewer overflows.* In some cities with older infrastructures, such as Richmond and Lynchburg, Virginia, the water that enters a stormdrain during a rainstorm enters the same pipes that take wastewater from homes and businesses. This mixture of wastewater and storm water travels to the cities' wastewater treatment plants. During times of heavy rain, the volume of this water coming into the wastewater treatment plant can overwhelm the capacity of the plant, thereby causing an overflow. In combined sewer overflow situations, untreated wastewater (including raw sewage and untreated pollutants) directly enters the receiving stream or river. Therefore, items flushed down the toilet can end up in our waterways. Millions of dollars are being spent in Virginia and across the U.S. to eliminate this problem.



It should be noted that in most towns and cities, storm drains flow directly to streams and rivers. Litter on sidewalks and streets and in gutters is swept into the storm drain system when it rains. Just as a drop of rain can travel from a small stream to a river to the Chesapeake Bay or the Atlantic Ocean, so can a piece of litter. According to the Ocean Conservancy, 60% to 80% of debris found on ocean beaches is washed, blown, or dumped from shore.

Behavior Behind the Debris

Deliberate littering and illegal dumping contribute debris to our waterways, as do other non-deliberate actions—such as having a piece of debris blow out of your car window or off your boat. Sometimes our trash cans will be knocked over by animals or the wind, resulting in more accidental litter. One important concept for students to grasp is that there is a behavior and a person behind every piece of debris we find in our waterways. Some of these behaviors are:

Litter from Recreational Activities and Convenience Food Consumption

This category includes trash from fast-food restaurants that is littered by people in cars, or is left behind after a picnic. People who litter fast-food items contribute a significant amount of debris to our waterways. Other items include bags, balloons, beverage containers, clothing, and toys.

Debris from Ocean and Waterway Activities

This category includes fishing-related items from recreational and commercial fishermen like nets, fishing line, and bait boxes. Debris can also come from offshore oil and gas rigs, and from ships (military, cruise, and commercial).

Litter from Smoking

This category includes cigarette butts, cigar tips, lighters, and the wrappers on cigarette packs. Smoking-related activities account for a tremendous amount of litter—in some places cigarette butts make up more than 85% of all littered items.

Illegal Dumping Activities

This category includes household waste, refrigerators and other appliances, building and construction waste, and sometimes entire cars.

Personal Hygiene and Medical Debris

This category includes items from sewers that overflow, diapers, needles, and other related items.

Whether these items enter the aquatic environment from dumping, litter, or accidental routes, debris not only looks ugly, but it can harm the animals and plants that make their homes in stream, lake, wetland, and coastal environments.

Types of Aquatic Debris

Every year, volunteers across the world participate in the International Coastal Cleanup, picking up aquatic debris and collecting data about the quantity and types of litter they find. The *top ten* list from these cleanups gives us a tremendous amount of information about the behaviors and activities that contribute most to the aquatic debris problem. The Top Ten items vary little year-to-year.

Plastics — A Special Problem

Plastic is widely used due to its light weight, strength, durability, versatility, and low cost. We use plastic bags, bottles, cups, forks, spoons, straws, and six-pack rings. Many toys are made from plastics, as are tools including strapping bands, and plastic sheeting. Plastic is also used in making packing materials and fishing gear. Plastics can take hundreds of years to break down, so they may continue to entangle and kill animals year after year. One study found that almost 90 percent of the debris floating on our oceans is plastic. The filters on cigarettes are also made from plastic fibers.

Top Ten Litter Items in the United States

In the 2001 International Coastal Cleanup, these items comprised 82% of all debris found in the U.S.

1. Cigarette butts/cigarette filters
2. Bags/food wrappers
3. Caps, lids
4. Beverage bottles (glass)
5. Beverage cans
6. Cups, plates, forks, knives, spoons
7. Beverage bottles (plastic) 2 liters or less
8. Straws, stirrers
9. Fast food Containers
10. Cigar tips

Top Ten Litter Items in Virginia

In the 2001 International Coastal Cleanup, these items comprised 85% of all debris found in Virginia.

1. Cigarette butts/cigarette filters
2. Bags/food wrappers
3. Beverage bottles (plastic) 2 liters or less
4. Beverage bottles (glass)
5. Beverage cans
6. Cups, plates, forks, knives, spoons
7. Caps, lids
8. Fast-food containers
9. Straws, stirrers
10. Tobacco packaging/wrappers

Any trash that is improperly disposed of can potentially enter a waterway and have negative impacts on aquatic animals, plants, and humans. Aquatic debris can be categorized in several ways:

- By material (plastic, metal, glass, cloth, paper)
- By source or by the activity which led the trash to be in the water. Some activities include convenience food consumption, smoking, fishing, illegal dumping, sports/ games, balloons used in advertising, etc.
- By impact the items have on the environment
- By biodegradable / nondegradable (Much of our solid waste contains synthetic materials that do not degrade quickly, if at all.)
- By recyclable / non-recyclable

Impacts of Aquatic Debris

Litter not only detracts from the beauty of a riverside park or beach, but also can be a health and safety hazard for humans, and aquatic wildlife. Another big impact of litter is the cost to society. Millions of dollars are spent every year in Virginia by state and local governments, parks, schools, and businesses to pick up litter.

Impacts on Aquatic Habitat

Habitat destruction or harm is caused when submerged debris (for example, a piece of plastic sheeting) covers seagrass beds, or smothers bottom-dwelling species. Some debris can also cause physical damage.

Impacts on Water Quality

Debris can also affect the water quality by adding chemicals to the water. Construction waste illegally dumped in a stream can include buckets that once held paints, solvents, and other chemicals that can enter the water. Cigarette butts and some other littered items contain toxic chemicals that leach into the water.

Impacts on Aquatic Animals—Entanglement and Ingestion

Aquatic debris can be particularly dangerous and often lethal to wildlife. Each year, more than 100,000 marine mammals die when they ingest debris or become entangled in ropes, fishing line, fishing nets, and other debris dumped into the ocean. As many as 2 million seabirds also die every year due to debris ingestion and entanglement. Fishing line, fishing nets, strapping bands, and six-pack rings can hamper the mobility of aquatic animals. Once entangled, animals have trouble eating, breathing, or swimming, all of which can have fatal results. According to the National Oceanic and Atmospheric Administration (NOAA), marine debris threatens over 265 different species of marine and coastal wild-life through entanglement, smothering, and interference with digestive systems.

Sea turtles, birds, fish, and mammals often mistake plastic items for food. For instance, sea turtles often mistake plastic bags for jellyfish, one of their favorite foods. With plastic filling their stomachs, animals have a false feeling of being full, and may die of starvation.

Impacts on Human Health and Safety

Trash in our waterways can also affect human health and safety. Hazards include glass and metal left on the beach, or hospital needles and syringes that can carry disease. Fishermen and recreational boaters can also be endangered as nets and monofilament fishing line wrap around a boat's propeller. Plastic sheeting and bags can also block the cooling intakes on boats. Such damage is hazardous and costly in terms of repair and lost fishing time. A survey in Oregon revealed that nearly 60 percent of fishermen had experienced equipment damage due to marine debris, costing thousands of dollars in repairs.

Economic Impacts from Aquatic Debris

A tremendous amount of time, effort, and machinery is devoted in Virginia to cleaning up litter on the land and in our waterways. Many Virginian coastal communities and parks have regular beach sweeping to remove trash left behind by visitors. Virginia's Department of Transportation spends more than $6 million to remove litter from our roadsides in addition to the thousands of hours Adopt-A-Highway volunteers spend picking it up. For information on the Adopt-A-Highway program, see *http://www.virginiadot.org/infoservice/prog-aah-default.asp* College grounds maintenance crews spend thousands of hours every year picking up litter, as do employees of restaurants, hotels, stores, and other businesses.

Every county in Virginia has a Litter Prevention and Recycling Coordinator. To find the coordinator in your county, visit this website: *http://www.deq.state.va.us/recycle/city-countylist.html*

Cigarette Butts—A Special Problem

According to data collected by the Ocean Conservancy, cigarette butts are the most common type of litter on earth, weighing in the millions of pounds. Trillions of cigarette butts are disposed of yearly, many directly tossed into the environment. Cigarette filters are made out of cellulose acetate, a plastic that takes several years to degrade.

Cigarette butts accumulate outside of buildings, on parking lots, and in streets where they can be transported through storm drains into streams and rivers. In addition to being unsightly, the chemicals that leach out of cigarette butt litter present a toxic threat to aquatic animals. The compounds in discarded cigarette butts (the filters and remnant tobacco) are biohazards to the water flea, *Daphnia magna*, a small crustacean at the lower end of, but important to, the aquatic food chain. Cigarette butts in the environment are an important litter issue - not a smoking issue.

In addition to costly cleanup procedures, there are other economic impacts that are harder to put a price on. Littered parks, marinas, and beaches suffer from lost tourist income, and fisheries that are full of debris can result in decreased yield of food such as crabs and fish.

Solutions to Aquatic Debris

Cleanup

One solution to the aquatic debris problem is cleaning up the trash using paid employees and volunteers.

Several groups organize volunteer cleanups in Virginia, and are happy to include school groups in their efforts to make our streams and beaches cleaner. The International Coastal Cleanup in Virginia, an annual statewide cleanup of all water bodies in Virginia, is organized by Clean Virginia Waterways, located at Longwood University in Farmville. In addition to this statewide event, there are several regional cleanup events held every spring including the James River Regional Cleanup (organized by the James River Advisory Council), Clean the Bay Day (organized by the Chesapeake Bay Foundation), and the Potomac River Cleanup (organized by the Alice Ferguson Foundation). Hundreds of local cleanups are also organized every year through the *Adopt-a-Stream* and Fall River Renaissance program (run by the Virginia Department of Conservation and Recreation), where groups of interested citizens adopt a stream in their area. Virginia also has dozens of *Friends of...* groups, including Friends of the Rappahannock, Friends of the Shenandoah River, and Friends of the Appomattox River. These groups offer a variety of stewardship opportunities for citizens and students. See the list at end of chapter for contact information.

Are Cleanups the Answer?

Cleaning up pollution after it has entered the water is important, but it can be only a temporary solution if the sources of pollution are not also addressed. As mentioned above, the costs associated with cleanups can also be high. While both pollution cleanup and pollution prevention are needed, when it comes to the very preventable problem of aquatic debris, emphasizing prevention will yield greater results.

Pollution Prevention

There are two main approaches to preventing litter and trash from entering our waterways.

1. Proper Disposal. Educate people on the need to dispose of their trash properly, and make it easy for them to do so.
2. Waste Reduction. Examine how much waste we produce, and find ways to reduce it.

Proper Disposal

What a difference proper disposal of waste can make! As seen above, the vast majority of the aquatic litter is from items we can all easily carry until we find a trash can. Fast-food wrappers, bottles, cans, and cigarette butts are more than 80% of the litter we find in our waterways.

Waste Reduction

In the United States, we have 4.6% of the world's population, but we produce about 33% of the world's solid waste. Each of us can make incredible strides in reducing the amount of waste we are responsible for creating by employing the three **"Rs"**–**Recycle**, **Reuse**, **Reduce**. For every item we recycle or reuse, there will be one less piece of trash that can become a part of the aquatic debris cycle.

People can reduce the amount of trash they dispose of by:

- Buying reusable items rather than disposable ones. This can include reusable lunchboxes, plates, cups, eating utensils, and food containers instead of disposable items.
- Reusing items several times before throwing them away.
- Recycling plastics, glass, metals, and paper, and buying recycled goods too.
- Choosing items that have the least packaging.
- Not buying helium-filled balloons, and discouraging the release of balloons. Ask communities to celebrate in a way that doesn't add these deadly balloons to our aquatic environment.

Balloons—A Special Problem

What goes up must come down! Balloons return to the land and sea where they can be mistaken for prey and eaten by animals. Sea turtles, dolphins, whales, fish, and seabirds have been reported with balloons in their stomachs. It is believed that they mistake balloons for jelly-fish which are their natural prey. In 1985, an infant sperm whale was found dead of starvation as a result of ingestion of an inflated Mylar balloon which had lodged in its intestines. Ribbons and strings tied to balloons can also lead to entanglement.

In 1991, Virginia joined a handful of states in banning the mass release of balloons. The law states:

> "It shall be unlawful for any person to knowingly release or cause to be released into the atmosphere within a one-hour period fifty or more balloons which are (i) made of a non-biodegradable or nonphotodegradable material or any material which requires more than five minutes' contact with air or water to degrade and (ii) inflated with a substance which is lighter than air."

Balloons released for scientfic or meteorological purposes are allowed.

- Composting kitchen and yard waste.
- Using rechargeable batteries and recycling them when their useful life is over.
- Using a canvas or string bag to carry groceries and other items.
- Using cloth napkins, dishtowels, and handkerchiefs instead of paper ones.

Laws and Regulations

Growing public awareness and concern for controlling debris in our oceans and waterways has led to international, national, and statewide laws that prohibit littering and the dumping of trash in waterways. In the United States and in Virginia, there are several laws regulating the use, disposal, and effects of solid waste on aquatic environments.

In 1988, the U.S. signed onto the International Convention for the Prevention of Pollution from Ships—called MARPOL for short—joining 64 other countries that signed this international protocol that made dumping plastic into the ocean illegal. After signing MARPOL, the U.S. passed the Marine Plastic Pollution Research and Control Act. This act makes it against the law to dump plastics at sea and in all U.S. navigable waters. Laws like this have reduced the amount of trash on our beaches and in our ocean. Even so, it is estimated that there are more than 46,000 pieces of plastic debris floating on every square mile of ocean today.

In Virginia, we have litter laws, and also a ban on the mass release of balloons (see box on page 7 of this chapter). To read Virginia's litter laws, go to the Virginia General Assembly's web site (*http://legis.state.va.us*) and select *Code of Virginia*. Type *litter* in the search box, and then click on *Submit*. You will see a list of statutes and regulations addressing this topic.

Litter as a Teaching Tool

For young students, litter is often the first thing they think of when they are asked to visualize pollution. And unlike less visible forms of aquatic pollution (pesticides, gasoline, oil, toxic chemicals, sewage), children can play a significant role in reducing the aquatic debris problem. They can help by cleaning debris out of a stream or off a beach, and they can also learn to dispose of all trash properly and never be a source of litter. Other ways litter can be a valuable teaching tool include:

- Teaching the connection between our actions and environmental impacts. Decisions we make can lead to pollution, or to a cleaner environment. The environmental consequences of our actions can be hard to predict.
- Understanding how trash becomes aquatic debris (storm drain connection).
- Participating in a cleanup activity, gathering data about the debris found, and analyzing the data can lead to a student's development of an environmental ethic, and heightened commitment to preserve water quality.

beauty, and wildlife. Participating in cleaning an area can help them realize that solving water pollution problems requires everyone's involvement.

- Cleaning up aquatic debris is one way students can have a direct and positive role in protecting our aquatic habitats.
- Animals are dependent on a safe and healthy habitat. Their water and land homes should be free from litter.
- Trash that is not in the right place (like a recycling bin, a trash can, or other waste container) is litter.
- Litter makes our communities less attractive and less healthy places to live in.

RESOURCES

For the teacher...

Marine Debris Education. National Oceanic and Atmospheric Administration (NOAA). *http://www.education.noaa.gov/books/debris/debris1.htm*
http://www.publicaffairs.noaa.gov/oceanreport/marinedebris.html

Pocket Guide to Marine Debris. The Ocean Conservancy (2002).

Trash in our Oceans—You Can Be Part of the Solution: Marine Debris Abatement. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds. *http://www.epa.gov/owow/oceans/debris/index.html*

Pollution Solutions: Litter Prevention Activities for Virginia Teachers. Virginia Department of Environmental Quality, Department of Environmental Education.

Virginia Department of Environmental Quality's Office of Litter Prevention and Recycling. *http://www.deq.state.va.us/recycle/*

For the student...

Marine Debris Coloring Book. National Oceanic and Atmospheric Administration (NOAA). *http://www.education.noaa.gov/books/debris/debris1.htm*

WATERWAYS CLEANUP EVENTS IN VIRGINIA:

The International Coastal Cleanup in Virginia (Every September) organized by Clean Virginia Waterways

Email: *cleanva@longwood.edu*
Phone: 434-395-2602
Web Site:
http://web/longwood.edu/cleanva

Clean the Bay Day (Every Spring) organized by Chesapeake Bay Foundation

Email: *chesapeake@cbf.org*
Phone: 757-622-1964
Web Site:
http://www.cbf.org/calendar/ctbd.htm

Potomac River Watershed Cleanup (Every Spring) coordinated by the Alice Ferguson Foundation

Email: *potomaccleanup@fergusonfoundation.org*
Phone: 301-292-6665
Web Site: *http://www.fergusonfoundation.org*

James River Regional Cleanup (Every Spring within the counties of Chesterfield, Henrico, Powhatan, Goochland, Cumberland, and Charles City and the cities of Richmond and Lynchburg) sponsored by the James River Advisory Council

Email: *conleyk@chesterfield.gov*
Phone: 804-748-1567
Web Site: *www.jamesriveradvisorycouncil.com*

Adopt-a-Stream and storm-drain stenciling programs sponsored by the Virginia Department of Conservation and Recreation

Phone: 804-692-0148
Web Site:
http://www.dcr.state.va.us/sw/adopt.htm

Fall River Renaissance (annually Sept 15 - Oct 15) sponsored by the Virginia Department of Conservation and Recreation

Phone: 804-786-5056
Web Site:
http://www.dcr.state.va.us/temp/frrhome.htm

Virginia also has dozens of *Friends of...* groups, including Friends of the Rappahannock, Friends of the Shenandoah River, and Friends of the Appomattox River. A list of these organizations can be found on this web site: *http://www.deq.state.va.us/cmonitor/links.html*

Classifying Aquatic Debris

Virginia SOL

- *Science* 1.8, 3.10
- *Social studies* 1.10, 2.10
- *Language arts* 1.3, 1.12, 2.3, 3.7
- *Math* K.17, 1.20

Objectives

Students will...

- Predict the effects on animals of different kinds of aquatic debris (litter) in water
- Discuss the concept of debris and entanglement
- Describe specific examples of hazardous effects of debris on wildlife
- Discuss other harmful effects of debris in water
- Classify different kinds of debris found in water
- Identify different ways that debris can find its way into the water
- Discuss ways to reduce harmful debris
- Make a display presentation to publicize harmful effects and different types of aquatic debris, and possible solutions

Materials

A large garbage bag of assorted trash items, provided by the teacher

Safety & Regulations

All trash objects should be cleaned and checked by the teacher before being handled by students. Avoid any sharp objects or materials containing harmful chemicals.

For the field trip to the water site, follow all safety procedures as described in the Introduction to this packet.

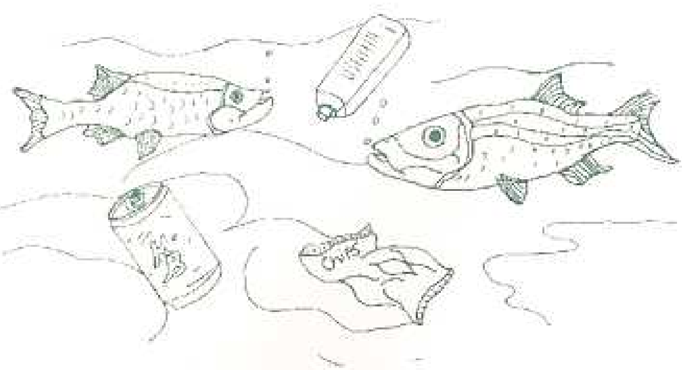
Time Needed

2 class periods, and additional time to visit local water site

What different kinds of litter can be found in local water and how can it cause harm to people and animals?

This lesson is designed to increase students' awareness of different kinds of debris in water environments. Many times we think first of debris on our beaches and in our oceans. However, debris is also found in other aquatic environments, such as streams, rivers, ponds and lakes. Litter on beaches and in waterways is more than an ugly eyesore. Now we realize that debris has serious detrimental effects. Animals and humans can be harmed, aquatic habitats can be destroyed or damaged, littered beaches must be closed or cleaned up, and it can be very costly to carry out cleanups or repair damage caused by debris.

Impact on animals is the first harmful effect of aquatic debris that most people think of. Fish, birds, mammals, and sea turtles can either ingest aquatic debris or become entangled. When animals ingest debris they have a false sense of being full and they can then die of starvation. Animals that become entangled in fishing line, six-pack rings, or other packaging become restricted in their movement. Entanglement makes it harder for the animal to eat and breathe and often leads to death. Plastic trash is a particular danger to animals.



Plastics have many desirable qualities and so are widely used, but plastics also take hundreds of years to break down. Plastic materials can also look very similar to some animal foods and so are often mistakenly ingested by animals.

Other harmful effects of aquatic debris include risks to human health and safety, for example from pieces of glass or metal, or such things as discarded needles and syringes. Boaters can be endangered by entanglement of boat propellers. Aquatic habitat is diminished or destroyed when debris covers submerged aquatic vegetation or smothers bottom-dwelling species. Chemicals from debris can have detrimental effects on water quality. And there are also economic impacts from aquatic debris. It is very costly to carry out clean-ups of trash and debris, and there are other indirect consequences such as lost tourist income to littered parks and beaches.

In this lesson, students will first discuss these harmful effects of aquatic debris. They will then sort household garbage or trash into different categories to understand some different types of aquatic debris, and they will also discuss different sources of aquatic debris. Lastly, the students will discuss some solutions to the problem of aquatic debris, and they will make a display presentation to publicize harmful effects of aquatic debris, different kinds of trash, and possible solutions.

Lesson Introduction

Begin the lesson by talking with children about how different kinds of trash in water can affect the animals living in that habitat. Discuss with them the concepts of debris and entanglement. Emphasize to the students that trash or garbage refers to waste being generated, and when it is improperly disposed it then becomes debris or litter. First, ask children to work in groups to predict some effects that debris might have on different animals. After the groups have shared their suggestions, describe to the children some specific examples of hazardous effects of debris on wildlife.

Debris in water can have harmful effects on wildlife, but the debris can also have other harmful consequences. Ask the students what other harmful effects they can think of, and then discuss some examples with them. Other harmful effects include hazards for humans as well as animals, impacts on aquatic habitats, and economic impacts from costly cleanups and lost tourist revenues. As harmful effects of debris are discussed, organize these on the board in different categories.

Have students summarize the different harmful effects of aquatic debris in their science journals.

Activity Procedures

Talk with students about different kinds of trash. Ask the children what different kinds of trash their families produce. Ask the students how the trash that their family produces might find its way into a stream, lake, or other water body. Ask the students if they have recently visited a river, a lake, or the ocean, and what trash they have seen near the water. Make sure students recognize that any trash that is improperly disposed is considered debris (litter) and can potentially enter a waterway and have negative impacts there.

Provide the class with a collection of trash. For safety reasons, the teacher should provide this trash. Students should not bring trash from home. This allows the teacher to be sure that students will not come into contact with any harmful objects. The trash should also be washed clean before bringing into the classroom. A large plastic garbage bag can be filled with cleaned trash in advance, and then the bag can be emptied out in the classroom, either on the floor or on a large table.

Have the students work in small groups to observe, describe, and then eventually classify the trash. First, allow each group to collect different pieces of trash for the group to study more closely. Let the groups talk about their collection of trash and the characteristics of each piece. After each group has had time for a discussion, direct each individual student to choose a *favorite* piece of trash. The students should then make a drawing of their object and also write a sentence describing the object in words. When the students have finished doing this, gather the groups together and show the whole group drawings and descriptions made by some of the students. Praise these students' work, and point out to the group how the students' drawings and descriptive words are successful in describing their objects.

Next, ask students in the large group to share words they used to describe their favorite piece of trash. Write these words on the board as the students share them. This should result in a good list of descriptive words. Read these aloud along with the class, so they can practice the words by reading them out loud. Leave these descriptive words written up on the board to help the children as they classify the trash items into groups.

For the classifying activity, begin by having each of the small groups work together to sort their own collection of trash objects into separate families. The students should sort their collection of objects into several smaller families of objects. Make sure to walk from group to group as the students do this and ask each group what it is that the objects grouped together share in common with each other. Usually the students will be grouping the objects based on the descriptive words that were used to communicate their earlier observations of the objects. When each group has sorted their objects, ask each group to join with a different group, and have the group spokesman explain for the other group how the sorting was carried out. Then the two groups should combine their objects and work together to reclassify the objects into families again, this time working as a larger group. Have the students complete the classification activity by each pair of groups working together to create a poster showing how they chose to do their final classification. The students can glue the families of objects of trash onto their poster board. They should label each of the families of objects that they create on the poster board with a descriptive word, and they should write a number for each family of objects.

Students could classify the objects of trash in a number of different ways. The most obvious way to classify trash and aquatic debris is by its appearance. For example, different objects are made of different materials, such as plastic, metal, glass, cloth, or paper. Objects can also be classified according to their source or what they were used for. Examples of different activities producing trash include convenience food consumption, smoking, fishing, other sports and games, advertising with balloons, and illegal dumping. Objects could also be classified as biodegradable or non-degradable, recyclable or non-recyclable, or by the type of impact they can have on the environment. Discuss with the class different ways that groups have decided to classify the trash, and tell students about some of the other possible ways that they may not have considered.

After the students have classified a selection of household trash, they should next discuss different ways that trash can find its way into water. Lead a classroom discussion of some of the different possibilities. These will include littering directly into waterways, dumping trash into storm drains, and dropping trash on a street served by storm drains. Trash can be deliberately tossed from a car or accidentally blown from a car or truck. Trash can also enter the water, either deliberately or accidentally, from commercial or recreational ships and boats. Illegal dumping and inadequate sewage treatment are two more ways that trash can reach water. List different ways that trash can get into the water on the board.

After the students have discussed in the classroom some different ways that litter can get into water, you might take the students on a visit to their local water study site. Have the students observe the water and its surroundings, with the focus for their observations being any signs of debris. The students should look for different kinds of debris, and they should also continue to think about the different ways that litter can reach the water.

Back in the classroom, have students write additional entries in their science journals to describe the work they have done and what they have learned from it. The students should summarize their classification of trash into different categories. They also should summarize what they have learned about different sources of aquatic debris.

The last thing for students to do, having learned about the harmful effects of aquatic debris, classified different types of trash, and discussed different ways that trash gets into the water, is to generate some possible solutions to the aquatic debris problem. Ask students to think about the reasons that people litter, and then suggest solutions that will change this behavior. The students should talk about this in small groups first and then share their suggestions with the whole class. One possible solution is to clean up debris from waterways regularly, using volunteers as well as paid employees. Two later lessons in this packet describe a simple cleanup for younger students and a more scientific clean-up for older students.

Cleanups, however, are only a temporary solution, and they do not address the sources of pollution. The two main approaches to preventing litter or debris from entering water in the first place are proper disposal of trash and waste reduction. People can be educated on the need to dispose of their trash properly, and ways can be found to make it easier for people to do this. Waste reduction involves examining how much waste we produce and finding ways to reduce this. The three **Rs** of waste reduction are **Recycle**, **Reuse**, and **Reduce.** Many littered items could be recycled over and over again. Many times we could choose to use a reusable product rather than a disposable product, thereby reducing the amount of waste we create.

Finally, have the class work together to create a display presentation to publicize everything they have learned about the harmful effects and different types of aquatic debris, and possible *pollution solutions*. This display presentation could be in poster form, or in the form of a three-dimensional model representing different kinds of trash and designed to show harmful effects along with possible solutions.

Questions

- What kinds of litter or aquatic debris have you seen around a river, a lake, or the ocean?
- How might different kinds of litter or debris be harmful to animals?
- What might you do to help stop animals being hurt by aquatic debris?
- What might you do to help reduce the amount of trash?
- Do you support or oppose requiring that grocery stores charge for bags to encourage consumers to use reusable shopping bags?

Assessments

- Science journal entry on harmful effects of aquatic debris.
- Science journal summary of classification of trash into different categories.
- Science journal entry summarizing what has been learned about different sources of aquatic debris and different ways that it can get into water.

- Classification poster with different objects of trash grouped together, each group numbered and labeled with a descriptive word.
- Display presentation publicizing harmful effects and different types of aquatic debris, and possible solutions.
- Have students draw pictures of an aquatic environment that is healthy for wildlife and an aquatic environment that is hazardous for wildlife. To go with their drawings, students can write a few sentences about how to help protect the wildlife.

Extensions

- Have students, after they have sorted objects of trash into categories, count the number of objects in each different category. Have the groups of students create bar graphs showing the number of objects in each category according to their classification. You can also combine the tallies for the whole class and have students prepare another bar graph for the class data.
- Help students survey their school grounds or community for litter. If there is a serious litter situation, help students to develop a plan to address the problem and raise public awareness.

Resources

For the teacher...

- Aching Gull. *Pollution Solutions: Litter Prevention Activities for Virginia Teachers.*
- Henry Heron, A Litter Story. *Pollution Solutions: Litter Prevention Activities for Virginia Teachers.*
- Marine Debris: Sources and Impact. *Save Our Seas.*
- Plastic Dumping Simulation Game. *Plastic Debris Teaching Activities.*
- Stash the Trash. *Pollution Solutions: Litter Prevention Activities for Virginia Teachers.*
- Tangled in Trash. *Waterways: Links to the Sea.*
- Turning Back the Plastic Tide: Will Plastic Take Over Our Oceans and Beaches? Price, B. (1988). *ScienceWorld, 44*(18), 8–11.
- Virginia Department of Environmental Quality Office of Litter Prevention and Recycling. *www.deq.state.va.us/recycle*
- Wildlife and Marine Debris. *Save Our Seas.*

For the student...

- *Prince William.* Rand, G. (1994). Henry Holt & Company. (Caring for a baby seal caught in an oil spill.)

Teaching The Science Process Skills

What Are the Science Process Skills?

Science and teaching students about science means more than scientific knowledge. There are three dimensions of science that are all important. The first of these is the content of science, the basic concepts, and our scientific knowledge. This is the dimension of science that most people first think about, and it is certainly very important.

The other two important dimensions of science in addition to science knowledge are processes of doing science and scientific attitudes. The processes of doing science are the science process skills that scientists use in the process of doing science. Since science is about asking questions and finding answers to questions, these are actually the same skills that we all use in our daily lives as we try to figure out everyday questions. When we teach students to use these skills in science, we are also teaching them skills that they will use in the future in every area of their lives.

The third dimension of science focuses on the characteristic attitudes and dispositions of science. These include such things as being curious and imaginative, as well as being enthusiastic about asking questions and solving problems. Another desirable scientific attitude is a respect for the methods and values of science. These scientific methods and values include seeking to answer questions using some kind of evidence, recognizing the importance of rechecking data, and understanding that scientific knowledge and theories change over time as more information is gathered.

Six Basic Process Skills

The science process skills form the foundation for scientific methods. There are six basic science process skills:

- Observation
- Communication
- Classification
- Measurement
- Inference
- Prediction

These basic skills are integrated together when scientists design and carry out experiments or in everyday life when we all carry out *fair test* experiments. All the six basic skills are important individually as well as when they are integrated together.

The six basic skills can be put in a logical order of increasing sophistication, although even the youngest students will use all of the skills alongside one another at various times. In the earliest grades students will spend a larger amount of time using skills such as observation and communication. As students get older they will start to spend more time using the skills of inference and prediction. Classification and measurement tend to be used across the grade levels more evenly, partly because there are different ways to do classifying, in increasingly complex ways, and because methods and systems of measuring must also be introduced to children gradually over time.

Integrating the basic science process skills together and gradually developing abilities to design fair tests is increasingly emphasized in successive grade levels, and is an expectation of students by fourth grade. The Virginia Standard of Learning (SOL) 4.1 for fourth-graders includes, for example, creating hypotheses and identifying and manipulating variables in simple experiments. At this level, the students are beginning to really ask and answer their own questions in a scientific sense. The following *Designing an Experiment* and *Analyzing Experimental Data* sections will focus on using the integrated science process skills to design experiments and reach conclusions.

In the Virginia Standards of Learning, the first science SOL (x.1) at every grade level K–12 tells which of the science process skills should be introduced and emphasized at that grade level. For grades K–6, where the SOL at each grade includes content from all areas of science, organized in strands across these grade levels, the science process skills SOL falls in the Scientific Investigation, Reasoning, and Logic strand. For grades 7–12 (Life Science, Physical Science, Earth Science, Biology, Chemistry, then Physics) the SOL are no longer organized in vertical strands, but the first SOL at each of these grade levels still defines the science process skills to be taught and practiced at that grade level. For all grade levels K–12, the intention is that the science process skills be taught and practiced by students in the context of the content SOL for that grade level. Students will work on different content areas of science during the year, and all year long they will continue to use and develop further the science process skills for their grade level.

Science Begins With Observation

Observing is the fundamental science process skill. We observe objects and events using all our five senses, and this is how we learn about the world around us. The ability to make good observations is also essential to the development of the other science process skills: communicating, classifying, measuring, inferring, and predicting. The simplest observations, made using only the senses, are qualitative observations. For example, the leaf is light green in color or the leaf is waxy and smooth. Observations that involve a number or quantity are quantitative observations. For example, the mass of one leaf is five grams or the leaves are clustered in groups of five.

Quantitative observations give more precise information than our senses alone.

Not surprisingly, students, especially younger children, need help in order to make good observations. Good, productive observations are detailed and accurate written or drawn descriptions, and students need to be prompted to produce these elaborate descriptions. The reason that observations must be so full of detail is that only then can students increase their understanding of the concepts being studied. Whether students are observing with their five senses or with instruments to aid them, we can guide them to make better more detailed descriptions. We can do this by listening to students' initial observations and then prompting them to elaborate. For example, if a student is describing what he or she can see, they might describe the color of an object but not its size or shape. A student might describe the volume of a sound but not its pitch or rhythm. We can prompt students to add details to their descriptions no matter which of the five senses they are using. There are other ways that we can prompt students to make more elaborate descriptions. For example, if something is changing, students should include, before, during, and after appearances in their observations. If possible, students should be encouraged to name what is being observed.

Observation and Communication Go Hand in Hand

As implied already, communication, the second of the basic science process skills, goes hand in hand with observation. Students have to communicate in order to share their observations with someone else, and the communication must be clear and effective if the other person is to understand the information. One of the keys to communicating effectively is to use so-called referents, references to items that the other person is already familiar with. For example, we often describe colors using referents. We might say *sky blue*, *grass green*, or *lemon yellow* to describe particular shades of blue, green, or yellow. The idea is to communicate using descriptive words for which both people share a common understanding. Without referents, we open the door to misunderstandings. If we just say *hot* or *rough*, for example, our audience might have a different idea of how hot or how rough. If a student is trying to describe the size of a pinecone they might use the size of his or her shoe as a referent. The pinecone could be either larger or smaller than his shoe.

The additional science process skill of measuring is really just a special case of observing and communicating. When we measure some property, we compare the property to a defined referent called a unit. A measurement statement contains two parts, a number to tell us *how much* or *how many*, and a name for the unit to tell us how much *of what*. The use of the number makes a measurement a quantitative observation.

Students can communicate their observations verbally, in writing, or by drawing pictures. Other methods of communication that are often used in science include graphs, charts, maps, diagrams, and visual demonstrations.

Classifying Into Groups

Students in the early grades are expected to be able to sort objects or phenomena into groups based on their observations. Grouping objects or events is a way of imposing order based on similarities, differences, and interrelationships. This is an important step towards a better understanding of the different objects and events in the world.

There are several different methods of classification. Perhaps the simplest method is serial ordering. Objects are placed into rank order based on some property. For example, students can be serial ordered according to height, or different breakfast cereals can be serial ordered according to number of calories per serving. Two other methods of classification are binary classification and multistage classification. In a binary classification system, a set of objects is simply divided into two subsets. This is usually done on the basis of whether each object has or does not have a particular property. For example, animals can be classified into two groups: those with backbones and those without backbones. A binary classification can also be carried out using more than one property at once. Objects in one group must have **all** of the required properties; otherwise they will belong to the other group.

A multi-stage classification is constructed by performing consecutive binary classifications on a set of objects and then on each of the ensuing subsets. The result is a classification system consisting of layers or stages. A multi-stage classification is complete when each of the objects in the original set has been separated into a category by itself. The familiar classifications of the animal and plant kingdoms are examples of multi-stage classifications. A useful activity for younger children could be to create a multi-stage classification of some local animals using physical and/or behavioral similarities and differences.

The Virginia Science SOL match the different classification skills to the different grade levels. In kindergarten, children are expected to sequence a set of objects according to size. The kindergarteners are also expected to separate a set of objects into two groups based on a single physical attribute. (See Science SOL K.1.) In first grade, students should classify and arrange both objects and events according to various attributes or properties (1.1). In second grade, students should classify items using two or more attributes (2.1). In third grade, students should classify objects with similar characteristics into at least two sets and two subsets, and they should also sequence natural events chronologically (3.1). In fourth grade, students should classify data to create frequency distributions (4.1);

in fifth grade, students should identify rocks, minerals, and organisms using a classification key (5.1); and in sixth grade, students should develop a classification system based on multiple attributes (6.1).

MAKING INFERENCES AND PREDICTIONS

Unlike observations, which are direct evidence gathered about an object, inferences are explanations or interpretations that follow from the observations. For example, it is an observation to say *an insect released a dark, sticky liquid from its mouth*, and it is an inference to state, *the insect released a dark, sticky liquid from its mouth because it is upset and trying to defend itself*. When we are able to make inferences, and interpret and explain events around us, we have a better appreciation of the environment around us. Scientists' hypotheses about why events happen as they do are based on inferences regarding investigations.

Students need to be taught the difference between observations and inferences. They need to be able to differentiate for themselves the evidence they gather about the world as observations and the interpretations or inferences they make based on the observations. We can help students make this distinction by first prompting them to be detailed and descriptive in their observations. Then, by asking students questions about their observations we can encourage the students to think about the meaning of the observations.

Thinking about making inferences in this way should remind us that inferences link what has been observed together with what is already known from previous experiences. We use our past experiences to help us interpret our observations.

Often many different inferences can be made based on the same observations. Our inferences also may change as we make additional observations. We are generally more confident about our inferences when our observations fit well with our past experiences. We are also more confident about our inferences as we gather more and more supporting evidence. When students are trying to make inferences, they will often need to go back and make additional observations in order to become more confident in their inferences. For example, seeing an insect release a dark, sticky liquid many times whenever it is picked up and held tightly will increase our confidence that it does this because it is upset and trying to defend itself. Sometimes making additional observations will reinforce our inferences, but sometimes additional information will cause us to modify or even reject earlier inferences. In science, inferences about how things work are continually constructed, modified, and even rejected based on new observations.

Making predictions is making educated guesses about the outcomes of future events. We are forecasting future observations. The ability to make predictions about future events allows us to successfully interact with the environment around us. Prediction is based on both good observation and inferences made about observed events. Like inferences, predictions are based on both what we observe and also our past experiences the mental models we have built up from those experiences. So, predictions are not just guesses! Predictions based on our inferences or hypotheses about events give us a way to test those inferences or hypotheses. If the prediction turns out to be correct, then we have greater confidence in our inference/hypothesis. This is the basis of the scientific process used by scientists who are asking and answering questions by integrating together the six basic science process skills.

In summary, successfully integrating the science process skills with classroom lessons and field investigations will make the learning experiences richer and more meaningful for students. Students will be learning the skills of science as well as science content. The students will be actively engaged with the science they are learning and thus reach a deeper understanding of the content. Finally active engagement with science will likely lead students to become more interested and have more positive attitudes towards science.

Resources

- A Key to Science Learning. Yockey, J. A. (2001). *Science & Children*, 38(7), 36-41.

  An article at the elementary school level, describing a simple writing technique to help students communicate the important science concepts they have learned.

- Centimeters, Millimeters, & Monsters. Goldston, J. M., Marlette, S., & Pennington, A. (2001). *Science & Children*, 39(2), 42-47.

  An article at the elementary school level, describing a humorous way to teach metric units.

- Drawing on Student Understanding. Stein, M., McNair, S., & Butcher, J. (2001). *Science & Children*, 38(4), 18-22.

  This article, at the elementary school level, describes how children can use drawings to communicate their understanding of animals. In the process, student learning about the animals is reinforced, as the children are encouraged to think deeply about what they know and have observed.

- *Learning and Assessing Science Process Skills*. Rezba, R. J., Sprague, C. S., Fiel, R. L., Funk, H. J., Okey, J. R., & Jaus, H. H. (3rd Ed.). (1995). Dubuque, IA: Kendall/Hunt Publishing Company.

  A comprehensive text describing both the basic science process skills and the integrated science process skills in detail, along with suggestions of activities incorporating the skills with science content and appropriate assessment methods.

- Oh Say Can You See? Checkovich, B. H., & Sterling, D. R. (2001). *Science & Children*, 38(4), 32-35.

  An article at the elementary school level, describing a simple strategy for improving students' observation skills.

- *Teaching & Learning The Basic Science Skills: Videotape Series*. Rezba, R. J. (1999). Office of Elementary and Middle School Instruc-tional Services, Virginia Department of Education, P.O. Box 2120, Richmond, VA 23218-2120. Call media office for copies of videotapes at 804-225-2980.

- When a Hypothesis is NOT an Educated Guess. Baxter, L. M., & Kurtz, M. J. (2001). *Science & Children*, 38(7), 18-20.

  An article at the elementary school level, discussing the difference between making a prediction (an educated guess about the out-come of a test) and forming a hypothesis (an educated guess about **why** the outcomes occurred).

Observing A Stream

Virginia SOL

- *Science* K.2, K.4, 1.8, 3.6, 3.10
- *Social studies* K.3, 1.5, 2.6
- *Language arts* K.2, K.11, K.13, 1.2, 1.12, 3.1
- *Math* K.10, K.17 1.12, 1.20, 2.12, 2.19, 3.14, 3.17
- *Technology* C/T5.2

Objectives

Students will...

- Discuss different water places that give students pleasure
- Predict characteristics of a local stream site
- Make observations of the local stream site with prompting from the teacher
- Observe stream surroundings, stream water, and stream bottom
- Describe the stream site in words, writing, and by drawing
- Generate questions of interest about the stream for further study
- Discuss stream observations and what they indicate about stream health
- Create a poster display to communicate observations and questions

Materials

For groups of three or four students

- Copies of *Observing a Stream Worksheet*
- Notebooks and pencils
- Cameras
- Compass and measuring string
- Clear plastic cups or bottles for water
- Other collecting equipment (plastic bags, tweezers, buckets, nets, etc.)
- Magnifying lenses
- A large map of the community
- Drawing materials and poster supplies

Safety & Regulations

Follow guidelines in the Introduction section *Planning a Safe Trip*. Adult chaperones are needed for the field trip. Students should not taste anything.

Time Needed

One class period, plus time for field trip

What are the detailed characteristics of a local stream?

Students will visit a site close to school that is suitable as a local water study site. The students will carry out a preliminary survey to discover information about local land use and water quality. After the visit, the students will document their fiindings by drawing and mapping the site. Students will also generate questions about the stream relating to land use or water quality that require further study.

The stream is part of a larger catchment basin or watershed. A watershed is the area drained by a water body. For example, thousands of creeks, streams, and rivers in Virginia ultimately drain into the James River. The land that these streams and rivers drain is considered the James River watershed. Some watersheds are very large, including the Chesapeake Bay watershed that drains 64,000 square miles of land in New York, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, and the District of Columbia. Other watersheds can be very small, measuring just a few acres.

For example, the parking lot of your school may drain into a nearby stream or pond that has a small watershed area. The topography of an area determines the shape of the watershed. The surrounding land and uses of the land influence the water quality of streams, ponds, and other water sites within the watershed. Field observations at the stream increase the students' ability to make connections between land characteristics in their watershed and water characteristics.

Vegetation beside the stream can decrease the amount and speed of water running off the land into the stream. This will help maintain water quality by reducing erosion, trapping soil particles, and absorbing nutrients from the runoff water. The vegetation also provides habitat for wildlife. Shade trees over a stream improve water quality in at least two ways. The shade lowers water temperature, which increases the dissolved oxygen content of the water. Also, leaves that fall into the water provide food for organisms living in the stream.

Inside the stream, diversity of water flow, with both slower pools and fast riffles, provides a variety of habitats for different animal species or the same species at different stages of its life cycle. Rocky stream bottoms are found in much of Virginia, including the Valley and Ridge and Blue Ridge Mountains. These streams offer a variety of current velocities as the water flows around the cobbles and pebbles. The rocks also provide attachment sites and hiding places for many animal species (mostly aquatic insects) and surfaces for algae to grow. For all these reasons, aquatic insects are usually found in great abundance and species diversity in Virginia's rocky bottom streams. In the Coastal Plain of Virginia streams are more likely to have sandy or muddy bottoms, and in Virginia's Piedmont the streams vary from rocky to sandy to muddy bottoms.

People often depend only on their sense of sight for making observations. In this lesson students should use other senses (hearing, smell, and touch) to obtain additional information about their environment. Using more of the senses provides a broader range of information and therefore an opportunity for greater learning. Students will create a display of the different observations they make at the stream site. A stream provides an ideal opportunity for people to use senses other than sight. Water can be heard as it moves through riffles and against stream banks. Wind makes sounds in vegetation around a stream, and insects and other wildlife also make sounds. Various chemicals in the water can cause it to smell, and there are also smells from earth and plants. The water can be touched, as well as other materials around the water. At all times, while exploring the stream, it is important to follow established safety procedures, and students should never be allowed to taste anything.

Lesson Introduction

Begin by asking students what they already know about local bodies of water. Include questions such as the following.

- Is there a lake, river, pond, or stream that you visit?
- What is your favorite pastime at this place?
- Why is this body of water important to you?

Discuss some local water sites with the students and together choose a stream that is close to the school and suitable for a class visit.

Review the five senses with the students. Discuss how the senses are used in daily life. Ask students about previous visits they have made to natural areas, and ask them how their senses were involved in those visits.

Ask students about how they make observations and discuss with them how to make their observations rich with details. Ask students to predict what they expect to observe when they visit the stream site. Finally, review the safety rules for the visit to the stream site. Safety rules are suggested in the Teachers' Guide section of this packet, under the heading *Planning a Safe Trip*.

Activity Procedure

At the water site:

For younger students...

Have the students walk around in groups, making observations and asking questions about the stream. Students can use the *Observing a Stream Worksheet* to record observations and questions. Ask the students to observe what is nearby the water and how the surroundings might affect the water. Collect a sample of water in a container and pour some of the water into clear plastic containers for the students to observe. Ask the students to observe the color of the water sample and what they see in the water. Ask students to observe whether the water in the stream is moving and how fast. Also ask students to observe the bottom of the stream. Ask groups to draw pictures of the study site. They should compare the water location to other features on the study site such as trees, hills, and buildings. Encourage the students to ask questions about the stream, including where the water comes from.

For older students...

Assign teams of students to observe different sections of the site. In teams made up of a journalist, a photographer, a sketcher, and a mapper, students should begin documenting observations for their section. Students should observe both the water in their section and the land bordering the stream. Students should record plants and animals observed in and around the water. Students should map the general contours of the land in their section and especially notice the slope of the land alongside the water.

Have students make observations of the stream and surroundings using four of their five senses. They should write observations on their *Observing a Stream Worksheet*, and also draw pictures. Ask the students to look at the water and surroundings and record what they see. Ask the students to listen to the water and surroundings and record what they hear. Ask the students to smell the water and surroundings and record what they smell. Ask the students to touch and feel the water and surrounding materials and record what they feel. Encourage students to block other senses while using one sense to make observations. For example, they might close their eyes while listening. Ask the students if they could hear better when they were not able to see.

Prompt students as they work to help them make good, detailed observations. This will help the students later as they attempt to understand new concepts. The *Observation Guide* is helpful for forming followup questions prompting students to elaborate on initial observations. The matrix is adapted from the article *Oh Say Can You See?* by Checkovich and Sterling (listed in Resources). The matrix includes prompts for students to elaborate observations made using each of the five senses as well as suggestions for other areas they may not have thought to observe.

Back in the classroom:

For younger students...

Ask the small groups of students to work together and communicate their observations made at the stream by completing pictures and maps of the site. Ask each group of students to share their observations with the class. Discuss the observations with the class. Ask students what they think their observations can tell us about the water quality and health of the stream. Have the students continue to brainstorm questions about the stream site that they would like to try and answer.

For older students...

Students from different small groups should create a joint display of all their drawings and maps. Work with the whole class to discuss and record similarities and differences of different sections of the stream site. As you discuss the students' observations about the stream site, ask students to speculate what the observations might tell us about the water quality and health of the stream. Have students work in their small groups to form questions about where the water comes from, how it flows through the site, and where it goes next. Also have the groups of students ask questions about how the area surrounding the water influences the quality of the water, particularly during periods of heavy rain, flooding, and snowmelt. Record questions asked by the students on a poster for the classroom.

Questions

- What plants and animals did you see?
- Was the stream fast or slow moving?
- Was the appearance of the stream different in different locations?
- How would you compare the feel of rocks collected from the stream with rocks from outside the water?

- What land use activities were taking place around the water?
- How did the water appearance compare for different sections of the water site?
- Was there evidence of water use either by humans or by animals?
- How do you think the water appearance would change in different seasons or different weather conditions?
- Based on its appearance, how would you rate the quality of the water?

Assessments

- Observe students working in groups at the stream and back in the classroom. Informally evaluate students on their group skills, their observations, their descriptions of the site, and the questions they ask.
- Have students make entries in their science journals/learning logs describing their observations and what they have learned about the stream. Students should list examples of sights, sounds, smells, and feelings observed at the stream site.
- Have students work in small groups to create displays of their observations. These should include observations about the surroundings of the stream, the water itself, and the stream bottom or substrate. Students can include both drawings and written descriptions.
- Have the whole class work together to create a visual display of what they have learned about the stream site. This should include information about the body of water, the surrounding land uses, and the impacts (positive and negative) of land uses on the water quality. This display can then be shared with others at the school and in the community.

Extensions

- Record measurement observations. The water and air temperatures could be measured at different locations at the stream site. Also, the speed of water flow can be measured by timing how long it takes for an object to float a certain distance. For example, if a colored ball or piece of wood held by a long string takes 10 seconds to float 20 yards downstream, then the water speed is 2 yards per second.
- Take students back to the stream periodically and have them record further observtions, then compare observations and note changes over time.
- If there are any signs of pollution or litter at the stream site, discuss this with the students. Talk with parents and other teachers about organizing a stream cleanup to collect and dispose of litter. Consult with experts first to ensure safety as well as proper disposal of collected litter.

- Have students prepare a written report of features and characteristics of the water site.
- Have students write stories describing adventures of different creatures living in the stream.
- Have students research how streams in other geographic regions of Virginia may differ from their own stream site.

Resources

For the teacher...

- At Home with Water. *Waterways: Links to The Sea.*
  Drawing favorite local water sites and learning of new ones.
- *Bay FAQ.* The Chesapeake Bay Program. *www.chesapeakebay.net/about.htm*
- Geology of Virginia. Virginia Department of Mines, Minerals, and Energy. *www.mme.state.va.us/dmr/DOCS/Geol/vageo.html*
- Life in the Fast Lane. *Project WET.*
  Investigating temporary wetlands in the neighborhood.
- Oh Say Can You See? Checkovich, B. H., & Sterling, D. R. (2001). *Science & Children, 38*(4), 32-35.
  An article at the elementary school level, describing a simple strategy for improving students' observation skills.
- Puddle Wonders. *Aquatic Project Wild.*
  Observing water and associated wildlife accumulated in puddles on or near the schoolgrounds.
- Stream Sense. *Project WET.*
  Using multiple senses to observe a stream.
- The Nature Walk: Looking for Animals. *Activities for Elementary School Science.*
- Water Walk. *Globe.*
  Exploring a local water site, observing the water and surrounding land use, and asking questions relating to the water and water quality.

For the student...

- *Wonders of Rivers (Learn About Nature).* Bains, R. (1989). Troll Communications.
- *Life is an Adventure.* A play for students about riparian habitats. Available from *www.vanaturally.com*

Observation Guide (Adapted from Checkovich & Sterling, 2001)

This Observation Guide provides suggested prompts for helping students make better, more detailed observations. The additional details will help the students later as they attempt to understand new concepts. The matrix is adapted from the article *Oh Say Can you See?* by Checkovich and Sterling (listed in Resources). The matrix includes prompts for students to elaborate observations made with each of the five senses, as well as other suggestions for enriching observations. Students should not be allowed to taste anything during the Observing a Stream lesson.

Making More Detailed Sense Observations

Look	Listen	Taste	Smell	Touch
Color?	Volume?	Sweet?	Sweet?	Texture?
Size?	Pitch?	Sour?	Sharp?	Density?
Shape?	Tone?	Bitter?	Rotting?	Hardness?
Position?	Rhythm?	Salty?	Burned?	How is it made?

Different Things to Observe

What is it you are describing?	Temperature?	Movement?
Can you compare it to something else?	Reflections?	Speed?
Patterns?	Shadows?	Sequence in time?
Markings?	Shiny?	Time of day?
Location?	Age?	How many?
Health?	What is happening?	Measurements?
How is it being used?	Behavior?	Geometrical shapes?
Wet or dry?	Expressions or gestures?	Neat or messy?

STUDENT HANDOUT

Observing A Stream Worksheet

What can you observe about the stream?

1. STREAM SURROUNDINGS

Describe what is on the banks of the stream and nearby.

2. STREAM WATER

Describe the water as well as how the water is flowing.

3. STREAM BOTTOM

Describe the bottom of the stream.

What are some questions you would like answered about the stream?

INTERNATIONAL PAPER

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